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Interagency Modeling Atmospheric Assessment Center local jurisdiction : IMAAC operations framework

Dadosky, Edward J.

Monterey, California. Naval Postgraduate School

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

INTERAGENCY MODELING ATMOSPHERIC ASSESSMENT CENTER LOCAL JURISDICTION: IMAAC OPERATIONS FRAMEWORK

by

Edward J. Dadosky

March 2010

Thesis Advisors: Richard Bergin
Robert Josefek

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13. ABSTRACT (maximum 200 words)

The Interagency Modeling Atmospheric Assessment Center (IMAAC) is a Department of Homeland Security (DHS) interagency working group responsible to create atmospheric air plume dispersion model predictions for designated emergencies. When 'activated' IMAAC is comprised of representatives from eight federal agencies with the National Atmospheric Release Advisory Center (NARAC) serving as the interim host. The Center concept was designed to eliminate contradictory plume predictions during weapons of mass destruction (WMD) and hazardous materials incidents. IMAAC plume predictions represent the federal position during such emergencies. IMAAC resources are also available to assist local jurisdictions during incidents requiring 'federal coordination' as cited by the DHS National Response Framework. An operations framework model has been devised in this thesis to address ongoing plume modeling issues between IMAAC and first responders in need of fast and accurate plume predictions during accidental or intentional spills, releases, or discharges of WMD or hazardous materials into the environment. The proposed operations framework model is designed to address related obstacles facing first responders including IMAAC Web-based and stand-alone models accessibility, incident "reach back" support, coordinated procedures, training, exercises, and funding.

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INTERAGENCY MODELING ATMOSPHERIC ASSESSMENT CENTER LOCAL JURISDICTION: IMAAC OPERATIONS FRAMEWORK MODEL

Edward J. Dadosky, District Fire Chief, Cincinnati Fire Department, Ohio
B.A., University of Cincinnati, 1988

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Author: Edward J. Dadosky

Approved by: Richard Bergin
Thesis Advisor

Robert Josefek
Co-Advisor

Harold A. Trinkunas, PhD
Chairman, Department of National Security Affairs

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LIST OF ABBREVIATIONS AND ACRONYMS

AFD	Akron Fire Department
AHJ	Authority Having Jurisdiction
CBRNE	Chemical Biological Radiological Nuclear Explosive
CHEMTREC	Chemical Transportation Emergency Center
CIN FD	Cincinnati Fire Department
CLE FD	Cleveland Fire Department
COL FD	Columbus Fire Department
COTS	Commercial-Off-The-Shelf
CTEH	Center for Toxicology and Environmental Health
DOC	Department of Commerce
DFD	Dayton Fire Department
DHS	Department of Homeland Security
DHHS	Department of Health and Human Services
DoD	Department of Defense
DOE	Department of Energy
DOJ	Department of Justice
DOT	Department of Transportation
EAS	Emergency Alert System
EMA	Emergency Management Agency
EOC	Emergency Operations Center
ERG	Emergency Response Guide
FEMA	Federal Emergency Management Agency
GAO	Government Accountability Office
GIS	Global Information Systems
HSEEP	Homeland Security Exercise Evaluation Program
HSGP	Homeland Security Grant Program
HSPD	Homeland Security Presidential Directive
IC	Incident commander
IED	Improvised Explosive Device

IMAAC	Interagency Modeling Atmospheric Assessment Center
LEPC	Local Emergency Planning Committee
LFD	Local fire department
LINC	Local Integration of NARAC to Cities
LLNL	Lawrence Livermore National Laboratories
MDC	Mobile data computer
MMRS	Metropolitan Medical Response System
NARAC	National Atmospheric Release Advisory Center
NASA	National Aeronautics and Space Administration
NEA	Nuclear Energy Agency
NEP	National Exercise Program
NIC	National Integration Center
NIMS	National Incident Management System
NOAA	National Oceanic and Atmospheric Administration
NPS	National Planning Scenarios
NRC	Nuclear Regulatory Commission
NRF	National Response Framework
NRP	National Response Plan
NTSB	National Transportation Safety Board
OFCM	Office of the Federal Coordinator for Meteorological Services and Supporting Research
OFM	Operations Framework Model
ORP	Ohio LINC Response Plan
OS	On scene
PTI	Public Technologies Institute
QA	Qualitative analysis
R-911	Reverse 911
SHSP	State Homeland Security Program
SIP	Shelter in place
SITU	Situational Planning Unit
STCC	Standard Transportation Community Code
TCL	Target Capabilities List

TEI	Training Exercise Integration
TFD	Toledo Fire Department
TIC	Toxic industrial compounds
TOPOFF	Top Officials Exercises
UASI	Urban Area Security Initiative
USCG	United States Coast Guard
USDOT	US Department of Transportation
U.S. EPA	United States Environmental Protection Agency
VBIED	Vehicle borne improvised explosive device
WMD	Weapons of mass destruction

I. INTRODUCTION

A. FOREWORD

August 28, 2005, a warm summer evening in Cincinnati was interrupted by reports of a railroad tanker car venting a toxic gas in the city's East End community. Upon arrival to the scene, responders were looking at a hazardous materials railcar emitting a large volume of whitish-grayish-colored gas traveling in the general direction and beyond this residential neighborhood. In addition to locally available specialized resources, calls for assistance were made to several agencies including the National Atmospheric Release Advisory Center (NARAC),[1] United States Environmental Protection Agency (U.S. EPA), the Center for Toxicology and Environmental Health (CTEH), the Chemical Transportation Emergency Center (CHEMTREC), as well as personnel at the All Hazards Training Center located at the University of Findlay (Ohio) and others.

As the incident progressed into the early morning hours, the primary question virtually everyone wanted to know was twofold: "What is it and where is it going!?" This question prefaced virtually every meeting, discussion, and press conference. The "what is it" part was relatively easy as the railcar was identifiable by the Standard Transportation Commodity Code (STCC) and properly placarded indicating the chemical styrene.[2] Fortunately, styrene is not the worst chemical to deal with during an emergency; however, significant challenges remained with the "where is it going" piece. Even with direct access to NARAC, it became painfully obvious during the course of this emergency that reliable plume modeling had to happen faster from a local perspective and with respect to plume predictions serving as immediately actionable intelligence with which to direct/protect the public during a hazardous materials or weapons of mass destruction (WMD) incident. It is not difficult to visualize a similar scenario where the

[1] The Department of Energy NARAC is the interim host to IMAAC.

[2] Styrene is used in the production of plastics, rubber, insulation and a multitude of other industrial uses. Styrene is mildly toxic.

release involves a more lethal chemical than styrene. Whatever the case, responders will interminably be asked and *expected to know*, “Where is the plume going?”

B. BACKGROUND

Primarily due to negative atmospheric air plume dispersion modeling issues experienced during National Top Officials (TOPOFF) Exercises,[3] the Department of Homeland Security (DHS) has dedicated resources to improve upon plume modeling response deficiencies with the 2004 formation of the Interagency Modeling Atmospheric Assessment Center (IMAAC). The IMAAC was established as the “…interagency center responsible for producing, coordinating, and disseminating (plume) predictions for airborne hazardous materials” (Government Accountability Office [GAO], 2008). The IMAAC is a partnership between DHS and seven other federal agencies: the Department of Energy (DOE), the National Oceanic and Atmospheric Administration (NOAA), the Environmental Protection Agency (EPA), the Department of Defense (DoD), the National Aeronautics and Space Administration (NASA), the Nuclear Regulatory Commission (NRC), and the Department of Health and Human Services (HHS). Currently, IMAAC is coordinated by Director Nicholas L. Wong, a U.S. Coast Guard Lieutenant Commander detailed to DHS’ Office of Operations Coordination and Planning (R-Tech, 2004).

IMAAC plume predictions represent the federal position for atmospheric air plume dispersion modeling during incidents that involve more than one federal agency. IMAAC is also available to give assistance to local jurisdictions for plume modeling for incidents requiring federal coordination. IMAAC fulfills this mission by providing a variety of resources, including Web-based and stand alone plume model programs that can be operated independently and become even more valuable when coupled with scientific expertise resident at the Center referred to as “reach back” support. The

[3] In 1999, the United States Congress ordered the Department of Justice to conduct an exercise “with the participation of all key personnel who would participate in the consequence management of [an actual chemical, biological, or cyber] terrorist event.” The exercise, to be called TOPOFF (for “Top Officials”) is intended to realistically test the federal, state, and local response and management systems; Several TOPOFF exercises have taken place since 1999 including those requiring atmospheric air plume dispersion modeling; United States Office of Justice Programs; Office of Domestic Preparedness (DHS, 2003).

Lawrence Livermore National Laboratories (LLNL) National Atmospheric Release Advisory Center currently serves as the interim IMAAC host.

C. DEFINITION OF THE PROBLEM

The emergency response community has historically been tasked to provide for the public's safety during many scenarios including the accidental or intentional release of toxic industrial compounds (TIC) or chemical, biological, radiological, nuclear, and explosive (CBRNE) materials into the atmosphere or environment.

Emergencies involving serious hazardous materials releases can result in a lethal plume extending several miles with the potential to kill people. Incidents such as the 1995 Tokyo subway sarin gas attack (Olson, 1999), 2003 Louisville catastrophic ammonia release (U.S. Chemical Safety and Hazard Investigation Board, 2004), and the 2008 South Carolina chlorine train car derailment (Mitchell, 2005), have proven especially challenging for several reasons including management of exposure injuries and fatalities. As noted in a 2010 study released by Rolf Mowatt-Larssen of Harvard's Belfer Center for Science and International Affairs, there is evidence supporting Al Qaeda's intention to use a crop duster to spray a chemical or biological agent on civilians and responders after the September 11 attacks in New York and Washington, D.C (Mowatt-Larssen, 2010). Whether accidental or terrorist in nature, one common thread of incidents of this nature is the distinct possibility of a toxic plume cloud necessitating the evacuation and/or shelter in place of entire communities. Ideally, these types of incidents would be prevented but history shows that such events will continue to occur in spite of our best prevention efforts.

It is alarming that according to the Department of Commerce (DOC) Office of the Federal Coordinator for Meteorological Services and Supporting Research (OFCM) that "most of the more than 140 documented model systems used for…emergency operations purposes…are limited in their ability to accurately predict the path of a plume…" (GAO, 2008). This is especially significant because according to some experts, if people in the vicinity of a damaged hazardous materials tanker truck can be alerted with specific and accurate directions they will be more likely to take appropriate protective actions such as

shelter in place (SIP) or evacuation (Auf Der Heide, 1989). Conversely, if people are not confident in direction given by public officials, they will be less likely to heed and may disregard altogether. Issuing appropriate and accurate warnings is one of the most important ways of averting the destructive consequences of disasters (Auf Der Heide, 1989). Furthermore, adopting a post-incident perspective with respect to public trust in government officials' ability to manage emergencies, Dr. Peter Sandman's formula of *Risk = Hazard + Outrage* (Sandman, 2010) could take on renewed significance dependent upon the publics' perception of overall incident management including alert notifications and guidance.

While the establishment of IMAAC is generally viewed positively, some criteria for local jurisdictions' eligibility for IMAAC access or assistance are deserving of a closer look. Criteria such as that found in the National Response Plan (NRP) whereby activation language states that IMAAC will support those incidents "requiring federal coordination" (Blonski et. al., 2007). This NRP language is in fact an improvement over the previously more-restrictive criteria that required an incident to rise to a level of "national significance" as a qualification for IMAAC aide. Nevertheless, the yoke of "requiring federal coordination" as an activation prerequisite could still limit a jurisdictions' ability to quickly apply IMAAC plume models to local incidents such as the 424 *serious* hazardous materials accidents occurring in 2008 (U.S. Department of Transportation [USDOT], 2009). In such cases, while awaiting for incident status to progress to an officially-recognized NRP federal coordination level, critical public protective action decisions may either be delayed, or worse, based solely on one of the 140 faulty plume models as previously noted by OFCM. Further analysis of IMAAC history regarding areas needing improvement includes a Government Accountability Office (GAO) recommendation for additional scrutiny to, "delineate the type and scale of major CBRNE incidents that would qualify for IMAAC assistance" (GAO, 2008). The underlying intent of this statement is unclear; however, this writer is opposed to access or assistance restrictions that could further inhibit responder access to IMAAC support especially important during the earliest stages of hazardous materials or terrorism incidents.

GAO cited issues related to system capacity and funding appear to be contributory factors limiting local jurisdictions' direct access to IMAAC Web-based or stand alone models. Other problems noted by GAO include inadequate first responder education and training accompanied by a lack of coordinated procedures between local agencies and IMAAC when working together during incidents or exercises (GAO, 2008). Absent a reasonable degree of integrated procedural understanding, it becomes ever more challenging to achieve a coordination level necessary to effectively manage catastrophic incidents involving air plume dispersions *especially* in the midst of a disaster. GAO has identified a significant gap regarding first responders' abilities to model hazardous materials releases.

To better illustrate the importance of rapid access to IMAAC support, substitute "chlorine" for "styrene" in the incident described earlier. Consider assignment as incident commander (IC) of Cincinnati Fire District 3 stationed by a major rail yard adjacent to downtown Cincinnati. An alarm is transmitted advising that a railroad tanker car has derailed and is aggressively venting a large volume of a greenish colored gas into the atmosphere. Among numerous other responsibilities (beyond the scope of this example) this IC is tasked to model the plume, alert the public, and to make public protective action decisions involving evacuation and shelter in place. If the IC does not have access to sufficient (fast and accurate) plume model capabilities, citizens and responders may be unnecessarily placed in danger due to delays in receiving direction, or worse yet, receiving *bad* direction. Subsequent conference calls, disaster declarations, federal coordination, etc., are *at best* several hours away and in place long after this chlorine plume has had a potentially devastating impact on the city. The potential for these kinds of accidents, and arguably terrorist attacks, is substantial for urban and rural areas throughout the nation. This is one hypothetical example of negative consequences for local jurisdictions absent fast and accurate atmospheric air plume dispersion modeling capabilities and support and is the paradigm through which this thesis is written.

D. THESIS STATEMENT

This thesis involves the development of an Interagency Modeling Atmospheric Assessment Center local jurisdiction operational framework model enabling direct and immediate access to IMAAC by high risk jurisdictions as defined by the DHS Urban Area Security Initiative (UASI) and Metropolitan Medical Response System (MMRS) programs.

E. RESEARCH QUESTION

Research Question: What enhancements can be made to the Department of Homeland Security Interagency Modeling Atmospheric Assessment Center Program to improve atmospheric air plume dispersion model capabilities of first responders for hazardous materials or WMD emergencies?

1. What procedural model can be developed that provides immediate and direct support from IMAAC to high risk local jurisdictions during incidents requiring air plume dispersion modeling assistance?

2. What funding sources can be utilized for IMAAC capabilities enhancements to joint IMAAC-local jurisdictional procedures, training, and exercises, as well as an anticipated increase in calls for assistance from high risk urban areas and other local jurisdictions?

3. What existing programs could be applied to the development of comprehensive plume model training and exercises designed to improve high risk local jurisdictions' capacity to utilize and coordinate with IMAAC?

F. ARGUMENT

Simply stated, the Department of Homeland Security has formulated the Interagency Modeling Atmospheric Assessment Center to create accurate atmospheric air plume dispersion model predictions that graphically depict where toxic and poisonous gases travel during a related emergency. Arguably, and speaking as a U.S. citizen, the author expects the eight partner agencies to work collaboratively to develop and sustain industry-leading plume modeling capabilities required by federal emergency planners, managers, and decision makers. It is critical for the federal government to have access to

reliable plume predictions. It is also critically important that local first responders have immediate/direct access to the same science that provides congruence with Homeland Security Presidential Directive (HSPD) 5 and, specifically, with HSPD 8, Paragraph 5, Article B (DHS, 2003).

The author's claim is that IMAAC direct access and ongoing incident support should be made directly available to high risk local jurisdictions during the *earliest* (initial) stages of hazardous materials or weapons of mass destruction incidents. High risk jurisdictions are defined in this thesis as the 64 high threat Urban Areas as identified by the 2010 DHS Urban Area Security Initiative (UASI) program (DHS, 2009). If successful, IMAAC would then be enhanced to support additional high risk urban areas including the one 124 DHS Metropolitan Medical Response System (MMRS) jurisdictions (DHS, 2009).

IMAAC has been identified by DHS as the sole source of plume predictions for incidents requiring federal coordination, and consequently, has become the source for atmospheric air plume dispersion modeling for national emergencies (GAO, 2008). IMAAC plume models are formulated based on chemical properties, real-time weather, and topographical information, the amalgamation of which is not readily available in Commercial-Off-The-Shelf (COTS) software used by many emergency response agencies. During research performed in this thesis, 10 randomly-selected UASI fire departments were contacted and all relied on the National Oceanic and Atmospheric Administration (NOAA) Computer-Aided Management of Emergency Operations (CAMEO)[4] system, COTS models, or a combination of both. None were familiar with IMAAC. Currently, emergency responders are reliant on one of the 140 atmospheric plume models identified as *deficient* by the Office of the Federal Coordinator for

[4] The U.S. EPA/NOAA CAMEO system integrates a chemical database, an air dispersion model (ALOHA), and mapping capability (MARPLOT) that can be used to formulate plume predictions during related emergencies. The entire system is often generically referred to as "CAMEO" to include the plume model and mapping feature. CAMEO plays an important role in related emergency response and planning; IMAAC incorporates Cameo-Aloha-Marplot calculations to help adjust or validate some short-term IMAAC plume model predictions. In no way is this thesis intended to disparage the ongoing value of the U.S. EPA/NOAA Cameo-Aloha-Marplot System to the emergency response and planning community. Areas that make sense to integrate CAMEO and IMAAC are in keeping with underlying IMAAC foundations.

Meteorological Service and Supporting Research (OFCM) (GAO, 2008). Incident-related decisions are often based solely on one of these faulty plume models. IMAAC plume predictions are *not* perfect; however, the models on which the author's colleagues and he have become fundamentally dependent are arguably a *lot less perfect.* Because local assistance from IMAAC remains limited by the National Response Plan (NRP) to incidents requiring federal coordination, responders' access to Center support could be significantly delayed during an accidental or terrorist spill, release, or discharge of a hazardous material into the atmosphere, placing the public in harm's way.

First responders tasked with the public safety have a limited margin of error when making evacuation and shelter-in-place decisions necessary to prevent injuries and save lives during disasters requiring atmospheric plume dispersion modeling coordination. In a hearing before the Homeland Security and Governmental Affairs Committee, Carolyn W. Merritt, Chairman and Chief Executive Officer, U.S. Chemical Safety and Hazard Investigation Board, summarizes that during many chemical releases citizens typically are not provided good directions, and "…large numbers of people are actually moving in the direction of the cloud of toxic gas" (U.S. Senate Hearing 109-62, 2005). In many scenarios, people may not be told where to evacuate because responders are incapable of appropriately directing people in part due to plume prediction deficiencies. Providing emergency responders immediate access to IMAAC models will improve plume modeling prediction capacity of local jurisdictions potentially lessening citizens and responders' exposure to toxic and poisonous gases. Delaying emergency responders' access to support because an incident has not risen to a level requiring federal coordination is short-sighted and counterintuitive to the "all incidents are local" mantra validated by HSPD 8 and addressed in greater detail in elements of the Department of Homeland Security National Response Framework (NRF). On page 10, the NRF outlines an accurate description of incident progression and highlights, "*A basic premise of the Framework, is that incidents are generally handled at the lowest jurisdictional level possible* [emphasis added]" (DHS, 2008) supporting my claim that IMAAC be made available directly and immediately to local fire departments which will be discussed in later chapters.

In order for select local jurisdictions[5] to receive immediate support from the Interagency Modeling Atmospheric Assessment Center, issues to enhance the Center need to be examined. As interim IMAAC host, existing capacity at Lawrence Livermore National Laboratories (LLNL) will need to be expanded in order to meet an expectant but unknown increase in service demands. Technology upgrades and additional personnel accompanied by procedural improvements will all be required in order for the IMAAC services to be made directly available to local jurisdictions. As such, some existing DHS programs and funding streams can be leveraged to address an increased demand on IMAAC resources resultant from an increased number of system users. For example, DHS programs such as the National Incident Management System (NIMS) can be used to strengthen procedural shortcomings identified in GAO-08-180 (GAO, 2008). Other programs including the Federal Emergency Management Agency Training and Exercise Integration (TEI) Program can be exploited to help adequately train responders to create and interpret plume models. Training exercises utilizing the Homeland Security Exercise and Evaluation Program (HSEEP) will be of value in measurement of training effectiveness to varying degrees dependent on the skill-sets to be evaluated. Funding for IMAAC enhancements to Center personnel and system capacity can possibly be achieved by the reallocation of some existing DHS budget dollars. This reallocation used to strengthen IMAAC would be coordinated with the State Homeland Security Grant (SHSG) and Urban Area Security Initiative programs to enhance local personnel capabilities and systems upgrades for the 64 DHS UASI jurisdictions.

Finally, an ongoing investment by DHS and the IMAAC partner agencies in support of plume modeling science and capabilities upgrades is critical to making direct access by local jurisdictions to support from the Center a worthwhile strategic objective. Access to substandard plume models will not enhance responder or public safety during a related incident regardless from where deficient models may emanate. Atmospheric air plume dispersion model science must remain cutting-edge and adequately funded to keep pace with the emerging hazardous materials and weapons of mass destruction threats that

[5] DHS-defined Urban Area Security Initiative (UASI) jurisdictions.

continue to face the nation. As stated by Albert Einstein," The problems that exist in the world today cannot be solved by the level of thinking that created them."

G. THESIS DESIGN

This thesis was designed to examine IMAAC from the perspective of local fire departments but with due consideration of diverse perspectives of various disciplines that will play a pivotal role in creating updated plume predictions and providing ongoing information and analysis necessary for long-term incident management. Strategies based on plume model formulation, interpretation, analysis, and application are a multi-disciplinary team effort and integral to intermediate[6] and long-term[7] incident management as related to atmospheric air plume dispersion modeling activities.

Experienced fire department command and planning officers were selected for interviews based on substantive involvement with either the LINC[8] or Ohio LINC[9] programs. LINC and Ohio LINC were designed to make the National Atmospheric Release Advisory Center plume prediction model programs immediately and directly accessible to predefined disciplinary representatives including local fire departments. NARAC has been designated by DHS as the interim IMAAC host. The author's LINC and Ohio LINC experiences have provided much of the underlying basis for this thesis, which attempts to build upon LINC concepts from the perspective of the fire discipline—arguably the most likely to arrive first on the scene of a hazardous materials or weapons of mass destruction emergency.

Literature that focuses on various aspects of atmospheric air plume dispersion modeling was reviewed and contributed to development of the proposed Operations Framework Model described in Chapter III. Literature and practical experience related to

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[6] Intermediate incident management would be for the first 30 minutes to 60 minutes.

[7] Long-term incident management would be greater than 60 minutes.

[8] Local Integration of NARAC to Cities; NARAC: National Atmospheric Release Advisory Agency; The LINC program was designed to make NARAC plume modeling support directly available to emergency planners and responders.

[9] The LINC Program as applied to the Ohio cities of Akron, Cincinnati, Cleveland, Columbus, Dayton and Toledo.

the aforementioned LINC and Ohio LINC programs, DHS Homeland Security Grant Program National Incident Management System, FEMA Training Exercise Integration Program, and the Homeland Security Exercise Evaluation Program, were foundational to the Operations Framework Model (OFM) formulated in this thesis.

The methodology used was the qualitative analysis of interview data gathered from disciplinary experts working for high risk urban areas as defined by the DHS UASI and MMRS Programs. In addition, fire disciplinary interviewees were selected based on the researcher's past experience with LINC, Ohio LINC, and coordination with IMAAC during the 2005 railcar hazardous materials release described earlier. During this roughly three and half day incident, the researcher had the opportunity to work directly with IMAAC from Cincinnati on day one and day two. The researcher traveled to Livermore, California *during the ongoing incident* and worked directly with IMAAC from LLNL on the Cincinnati styrene railcar incident on the second full day of this incident.[10] It was during this event and with the opportunity to view IMAAC substantively from both sides of the equation that additional revelations about IMAAC and local jurisdiction coordination requirements were revealed either directly or intuitively to the researcher. This experience became much of the incentive for this thesis.

After interviews were conducted with fire department disciplinary representatives (described more fully in Chapter V), the models were slightly refined based on interview responses. Changes with respect to certain model elements such as the funding sources and originally proposed response times associated with the OFM were the subject of most of the constructive criticism and proposed alterations. The model adjustments led to a hybrid model that was the basis for many of the findings and recommendations made in this thesis. The hybrid model and altered components are addressed in Chapter VI.

[10] Coincidentally, the researcher was *already* scheduled to attend an (unrelated) Department of Homeland Security Regional Technology Integration Initiative (RTII) meeting in San Francisco on these dates. The decision was made (locally) to have the researcher continue to the scheduled DHS meeting after first reporting directly to IMAAC (LLNL) to assist with the Cincinnati incident directly from the IMAAC Operations Center. The researcher had a unique opportunity to be involved with management of the same incident from the field (Cincinnati) and from IMAAC.

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II. LITERATURE REVIEW

This review will focus on information applicable to elements of the Interagency Modeling Atmospheric Assessment Center program with potential related impacts on the public safety from an emergency responder perspective. Sources come from many areas including government reports and programmatic literature, Local Integration of NARAC to Cities (LINC) project history, and hazardous materials release case studies. These and other resources offer insights into potential solutions for atmospheric air plume dispersion modeling problems identified in the Government Accountability Office report GAO–08–180.

Focus on hazardous materials incidents provided parallels to the emerging role of plume modeling in homeland security for chemical, biological, radiological, nuclear, explosive (CBRNE) response. Information related to specific incidents such as the Graniteville, South Carolina chlorine railcar derailment (National Transportation Safety Board [NTSB], 2005) and the Bhopal, India methyl isocyanate disaster (Routledge et al., 2005) offers rationale for the criticality of accurate plume modeling capabilities. The need for relatively fast, but more importantly accurate, plume predictions could become a factor if faced with biological incident consequences such as the anthrax release at Sverdlovsk (Alibek, 1998) or a radiological incident similar to that occurring in Chernobyl (Nuclear Energy Agency [NEA], 2002) in the former Soviet Union. Lessons learned from these and other disasters have provided a lens through which to view the importance of accurate air plume dispersion modeling capability. The value of fast access to accurate plume predictions by local jurisdictions for planning and response was validated by review of such incidents as the Flint, Michigan industrial plastics fire resulting in the treatment of 96 people exposed and the evacuation of 150 people from the surrounding area (Copeland, 1988).

The Interagency Modeling Atmospheric Assessment Center is a relatively new program taking shape as a result of conflicting plume model predictions occurring during Top Officials (TOPOFF 2) Exercises (Office of Inspector General [OIG], 2005). Review

of the TOPOFF 2 after action report provides useful insight into the complexity of the plume modeling community and the importance of accurate information becoming quickly available to first responders. Lessons learned during subsequent TOPOFF exercises (National Exercise Program [NEP], 2007) provided examples of the importance of non-conflicting plume model results on which to base emergency responder incident action planning.

The GAO report (GAO–08–180) also provides details about the importance of accurate plume predictions and affirms the lack of accurate plume model capacity currently available to local jurisdictional incident commanders nationwide (GAO, 2008). The respective GAO report acknowledges the role of local responders' as first on-scene for almost all emergencies and the importance of having access to the best information on which to base public protective decisions such as evacuation and shelter in place. In many cases, incident commanders are faced with life and death decisions under the worst possible circumstances amplifying the importance of having the best information immediately available to on scene managers. This perspective is an underpinning of much of the U.S. Department of Homeland Security National Response Framework (DHS, 2008) and receives added emphasis throughout GAO-08-180.

Other federal government guidance, such as Homeland Security Presidential Directive (HSPD) 5 and HSPD 8 (DHS, 2003), highlight the importance of federal, state, and local collaboration in order to improve incident outcomes. HSPD 8 gives added emphasis to the value of support for local jurisdictions for homeland security and all hazards incidents planning and response. This theme is repeatedly highlighted by the Department of Homeland Security and stresses the importance of supporting local emergency mangers with the best tools and information necessary to improve incident planning and response capacity.

As stated in the National Response Framework, "…incidents begin and end locally and most are wholly managed at the local level" (DHS, 2008). The NRF also states that incidents must be managed at the lowest possible jurisdictional levels and supported by other capabilities as needed. The idea of keeping incidents small and from rising to a level of "national significance" is a smart practice that will enhance the safety

and security of the nation. Derived from a recurrent national planning theme of "all incidents are local," one possible conclusion is that the best tools and information should be made available to first responders at the earliest incident stages in efforts to minimize the number of resources eventually needed to save lives and prevent the destruction of property. The importance of local jurisdictional access to the best plume modeling information is in concert with the underlying themes of the Homeland Security Presidential Directives and the National Response Framework. With respect to the IMAAC program, DHS appears to be somewhat in conflict with the National Response Framework by adopting a policy whereby incidents requiring federal coordination shall be the threshold for IMAAC assistance approval (Blonski et al., 2007).

Review of case history including that of six cities in Ohio (Public Technologies Institute [PTI], 2005) provides insights into local jurisdictions that receive direct support from NARAC[11] which had little impact on IMAAC system capacity. This is the only information that could be located that addresses a DHS concern that increased direct local jurisdictional access to IMAAC resources may overwhelm the Center, thus rendering the system inoperable due to a large increase in calls for assistance (PTI, 2005). Albeit very limited, the frequency of such requests for assistance in the Ohio case history did not overwhelm NARAC resources. Nevertheless, the literature and research with respect to IMAAC resources becoming overwhelmed resulting from an increased number of users is virtually non-existent and any related conclusions would be based more on supposition versus fact. It is very difficult to draw conclusions as to the exact increase in calls for service volume that might accompany an IMAAC system extended to the 64 DHS urban areas.

There are three examples with which the author was directly involved where plume modeling assistance from the National Atmospheric Release Advisory Center was provided directly to cities responding to chemical releases[12] where incident management and outcomes were improved as a result. The incidents did not go perfectly in part due to

[11] National Atmospheric Release Advisory Center has been designated as the interim IMAAC host from 2006-present.

[12] 2004 Cincinnati Hazardous Materials Warehouse Fire; 2005 Cincinnati Styrene Railcar Release; 2006 Ohio (near Cleveland) railcar release.

many of the issues identified by GA0–08–180. Other breakdowns included disjointed incident coordination, ineffective shelter-in-place message dissemination and conflicting messages issued by various agencies beyond the authority having jurisdiction (AHJ). Not all problems are fixed by IMAAC system access. The model proposed in this thesis is designed to enhance first responders' capabilities during the initial stages during these types of emergencies. The Graniteville, South Carolina train accident (NTSB, 2005) resulting in a catastrophic release of chlorine was eventually supported by IMAAC, but first responders in Graniteville did not have immediate IMAAC system access. This train disaster had injurious and deadly consequences for over 500 citizens in this community of about 5400 (NTSB, 2005). An accident similar to this one occurring in a densely populated urban area could be devastating.

A useful case history which bears some similarities to the proposed model includes five cities[13] involved in a national pilot program, the Local Integration of NARAC to Cities, that utilizes resources similar to that of the Interagency Modeling Atmospheric Assessment Center (LINC, 2003) and provides examples of how an IMAAC-type of system can be made directly available to local jurisdictions resulting in better incident outcomes. LINC was a program initiative between Public Technologies, Inc. and Lawrence Livermore National Laboratories sponsored by the Department of Homeland Security Chemical/Biological Countermeasures Program (LINC, 2003). According to Seattle Assistant Fire Chief A.D. Vickery, "From the viewpoint of a local first responder, LINC has achieved its primary objective very well (which is) to bring plume dispersion information directly to the incident commander to support imminent life-safety decisions" (LINC, 2003). IMAAC is currently hosted by Lawrence Livermore National Laboratories NARAC which also developed the LINC program. LINC provided five pilot cities with direct access to NARAC plume modeling software and technical "reach back" support.

The importance of training and exercises related to plume modeling is highlighted by GAO–08–180 and emphasizes that access to quality models is only one element of

[13] Albuquerque, NM (environmental-managed); Cincinnati, OH (fire managed); Ft. Worth, TX (GIS managed); New York (Emergency Management Agency managed) and Seattle, WA (fire managed).

improving responders' atmospheric plume modeling capabilities. It is problematic when local incident managers are not able to interpret or apply plume model results. The Federal Emergency Management Agency National Integration Center (NIC) through the Training and Exercise Integration program offers a sufficiently detailed methodology for training that could be applied to enhance responder skills synthesizing plume predictions (National Integration Center [NIC], 2009). Rather than create wholly new training programs, the FEMA TEI coupled with the FEMA Homeland Security Exercise Evaluation Program could provide a platform from which to educate and train responders nationwide. Further analysis of the HSEEP program might also provide a means by which to measure responder proficiency with air plume model application and interpretation by designing similar learning objectives into homeland security exercises. Additional DHS web based training focused on incident management will assist with IMAAC enhancements providing procedural and operational command structure improvements to areas cited as problematic in GAO–08–180. Elements of the respective Web-based training include the National Incident Management System comprised of NIMS 100, 200, 700, and 800 training courses (FEMA, 2009) as well as other Web-based training. A combination of DHS Web-based training and classroom sessions for NIMS 300 and 400 (FEMA, 2009) is consistent with HSPD 5[14] and a primary means by which the nation currently trains responders in incident management at all levels of local, state, and federal government. There are elements of NIMS training that will have applicability to an IMAAC training program particularly as related to the development and execution of coordinated procedures between IMAAC and local jurisdictions.

Additional funding for Interagency Modeling Atmospheric Assessment Center enhancements remains a challenge but a necessity if the program is to be extended beyond present Department of Homeland Security limitations. In this case, if IMAAC breadth expands to the level of local responder jurisdictions, a commensurate increase in funding would likely be necessary to enable an increased level of accessibility. In 2010, the DHS has budgeted just under 1.675 billion dollars for the UASI and State Homeland Security Programs (DHS, 2009). These grant programs are designed to better-prepare

[14] HSPD 5 instituted that National Incident Management System (NIMS).

local and state jurisdictions for consequences related to the DHS National Planning Scenarios (NPS), Target Capabilities List (TCL) and for all hazards emergencies. Review of prior DHS HSGP fiscal years showed precedence of DHS defining requirements within grant programs such as a 2008 mandate to spend 25 percent of all UASI grant awards on planning and improvised explosive device (IED) response enhancement. The literature demonstrated that grant guidance can be written by DHS to require respective grant recipients to spend a defined percentage of a grant award on a defined activity. In this case, that defined activity could be the enhancement of a jurisdictions' capability to model hazardous releases through training and exercises coordinated with IMAAC. Atmospheric air plume dispersion modeling as a key element of hazardous materials emergencies including literature detailing DHS National Planning Scenario (NPS) 6 (Toxic Industrial Compound) and NPS Scenario 8 (Chlorine Tank Explosion) could merit a grant program expenditure requirement similar to the IED requirement within 2008 UASI. Review of various other homeland security grant programs[15] could provide additional opportunities to adequately fund local IMAAC operational and system enhancements, training, and exercises to be implemented by local jurisdictions in coordination with the Interagency Modeling Atmospheric Assessment Center.

[15] Examples include: Emergency Management Grant Program (EMPG); Regional Catastrophic Preparedness Grant Program (RCPGP) and Buffer Zone Protection Program (BZPP).

III. MODELS

A. MODEL DESCRIPTIONS

The following figures (Figures 1, 2, 3, 4, and 5) are representative of an Operations Framework Model that would be applicable primarily to local jurisdiction fire departments and also to other support agencies in the context of an accidental or intentional spill, release or discharge of a hazardous material or weapon of mass destruction into the environment.

This chapter is designed to explain each block of each figure providing additional insight into what is represented in the individual actions or blocks of each model. Although most of the actions or blocks are intuitive, during some interviews additional explanation proved beneficial for the interviewee. Note: OFM 4 is a summary representation of NIMS integration into long term incident management for an incident requiring atmospheric air plume dispersion modeling.

1. Figure 1

Figure 1 is designed to provide an overall context and generalized perspective of the proposed OFM. This diagram is a wide-angle lens through which to view a local fire department role while incorporating IMAAC in the context of incidents potentially requiring atmospheric air plume dispersion modeling.

2. Figure 2

Figure 2 represents a break down of key tasks driving decision benchmarks for a local fire department beginning with incident on scene arrival up to and including transmitting a shelter-in-place directive to the affected population.

3. Figure 3

Figure 3 is similar to Figure 2. This diagram takes into account that internet Web-access may not always be available during emergencies, and in such cases, posits a viable alternative eventually issuing public protective direction such as shelter in place.

4. Figure 4

Figure 4 is representative of a proposed structure several hours into an incident and incorporating the National Incident Management System (NIMS) into long-term incident management focused specifically on atmospheric air plume dispersion modeling.

5. Figure 5

Figure 5 does not address incident scene management aspects as is the case in Figures 1, 2, 3, and 4. Figure 5 is representative of the building blocks necessary for many of the incident management objectives represented in Figures 1, 2, 3, and 4. Procedures, training, exercises, and funding perspectives are the basis for OFM 5 addressing key issues identified in GAO–08–180.

B. MODEL DETAILS

1. Figure 1

Figure 1 is a description of an incident life cycle focusing on shelter-in-place and evacuation public protective actions which may become decision points after a an accidental or intentional spill, release, or discharge of a hazardous material or weapons of mass destruction agent into the environment.

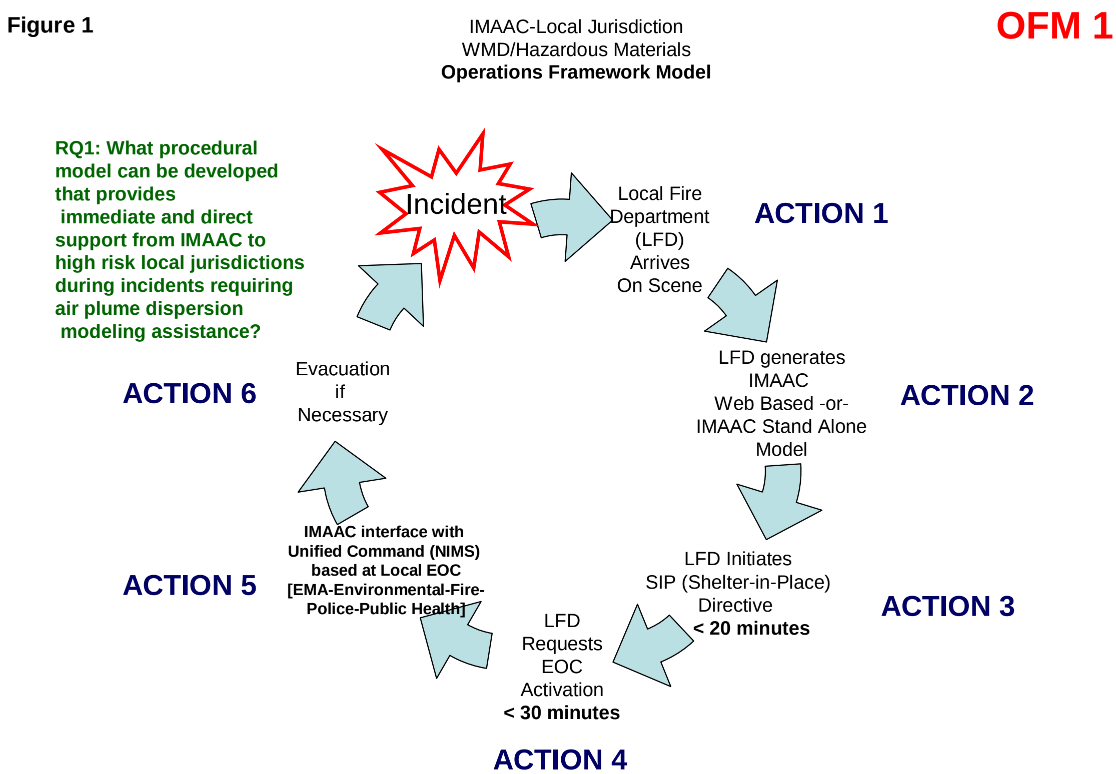

Figure 1. IMAAC-Local Jurisdiction WMD Hazardous Materials Operations Framework Model 1

Figure 1 begins with an incident as denoted by the model, and the subsequent actions are the focus of the IMAAC-Local Jurisdiction WMD Hazardous Materials Operations Framework Model. Incident benchmarks in Figure 1 are denoted as "actions" and are described below in more detail.

a. Incident

All scenarios which this model is designed to address begin with an incident of some type which is the starting point for this model. The incident described to interviewees was that of a chlorine tanker car (DHS National Planning Scenario 8) in a densely populated urban area. The tanker car markings, railcar placard, plume color, and other information provided immediately upon scene arrival were all strongly indicative of a catastrophic chlorine release.

b. Action 1

This action represents scene arrival by a either a hazardous materials team or a properly equipped and trained incident commander. "Equipped" in terms of adequate mobile data computer (MDC) internet access and "trained" in terms of the Interagency Modeling Atmospheric Assessment Center Web-site used to formulate a plume prediction.

c. Action 2

This action represents the formulation of an atmospheric air plume dispersion model either using the IMAAC Web or an IMAAC stand alone model.

d. Action 3

This action represents either an on scene incident commander or hazardous materials team working through a respective department or agency interface (i.e., dispatch center) to transmit shelter-in-place directives (SIP) to the effected population identified as in the path of the plume.

e. Action 4

This action represents a local fire department simply requesting that a jurisdiction's Emergency Operations Center (EOC) be activated and according to local protocols. Timeframes vary as to how fast a respective jurisdiction EOC would become staffed and operational, but a request for activation is made by the local fire department within 30 minutes from on scene arrival.

f. Action 5

This action represents the integration of the National Incident Management System into a local jurisdiction EOC organization and ongoing operations throughout an incident.

g. Action 6

This action represents that incidents may eventually pass a threshold where SIP is no longer effective and evacuation must take place. The timeframe is incident dependent. This author's claim is that while some may be able to self-evacuate (if advisable), institutions such as schools, day cares, hospitals, or nursing homes will not have an immediate evacuation capability. Therefore, many evacuation scenarios must first begin with SIP even if not preferable based on an incident source term or other circumstances.

2. Figure 2

Figure 2 describes benchmarks for a local fire department arriving on an incident scene requiring atmospheric air plume dispersion modeling. As described in Figure 1, Action 6 the key objective is to reach a decision point whereby an accurate shelter-in-place directive can be disseminated to the public based on IMAAC Web-based models.

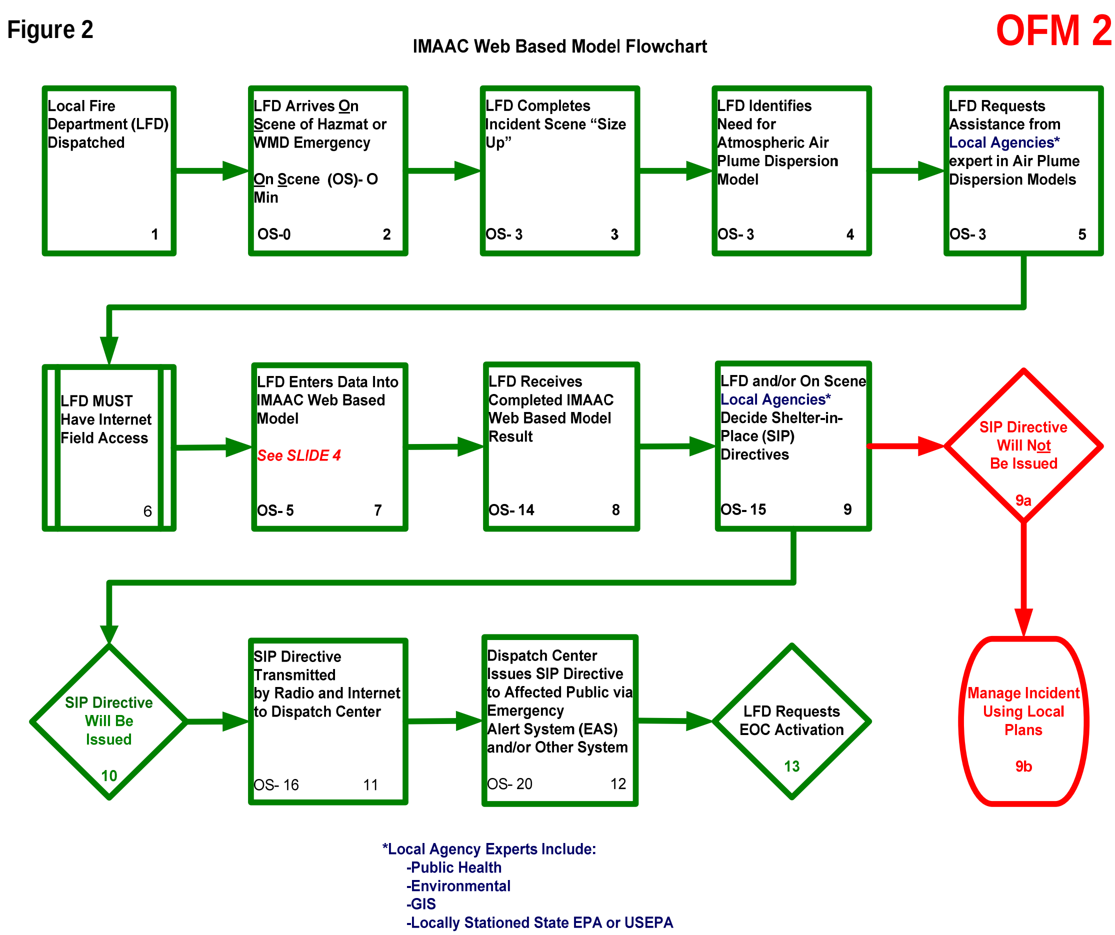

Figure 2. IMAAC-Local Jurisdiction WMD Hazardous Materials Operations Framework Web-based Model Flowchart

a. Block 1

Most incidents are reported to a dispatch center (i.e., 911 call centers) and the proper units are dispatched to an incident scene based on departmental dispatch protocol. The incident description provided by a caller is wholly subjective and will dictate the units dispatched to mitigate such an incident. Due to variations in jurisdiction protocol and potential for other uncontrollable incident reporting variables, the 20-minute mark for shelter-in-place initiation does not begin with the dispatch of units typically assigned for response to a hazardous materials or weapons of mass destruction incident.

b. Block 2

The time clock for OFM 2 begins with the arrival on scene of the hazardous materials team or properly trained/equipped incident commander. Because response times will vary for jurisdictions largely dependent on the proximity of incident location to the units dispatched, the time clock for OFM 2 does not begin until scene arrival by the respective units. Note: the notation “OS” stands for “On Scene” and all times are represented by (OS) minus (the minutes from scene arrival). OS–0 starts the clock. Times in subsequent blocks are represented by the same type of notation.

c. Blocks 3, 4, and 5

The incident commander is gathering and processing relevant incident information in the first three minutes from on scene arrival. During this timeframe, a properly trained incident commander or hazardous materials team can have acquired enough information in order to reach a conclusion that atmospheric air plume dispersion modeling will be useful in helping manage short-term and long-term consequences associated with the respective incident.

Note: In the first three minutes, the hazardous materials team or incident commander shall request assistance from locally positioned support agencies such as global information systems (GIS), law enforcement, public health, and local, state, and federal environmental protection agencies.

d. Block 6

In order for the IMAAC Web-based model to become a viable option, the local hazardous materials unit or incident commander requires internet connectivity to access and operate the IMAAC Web-based model.

e. Block 7

A properly trained hazardous materials team or incident commander can access the IMAAC website and enter the required information into the IMAAC Web-based model in five minutes or less.

f. Block 8

A properly trained hazardous materials team or incident commander will receive and have access to an IMAAC plume model prediction in 14 minutes or less from the time of arrival on scene. The plume model prediction is generated by IMAAC software and remains accessible to the hazardous materials team or the incident commander as long as IMAAC website access remains viable.

g. Block 9

Based on the plume model result and additional scene information acquired while waiting for the plume prediction to be calculated and returned by IMAAC, a properly trained hazardous materials team or incident commander could reach a decision to issue a shelter-in-place directive to the effected population. This decision would be made according to jurisdiction protocol and in collaboration with other local agencies that may have arrived on scene or established contact with the incident scene after receiving a request for assistance as previously described in Block 5.

h. Block 9a and 9b

Further information could lead to a decision to forgo a shelter-in-place directive. For example, it may be that a non-hazardous release was misidentified "as a hazard" and additional information obtained has effectively ruled out a hazard; or maybe the plume has almost completely dissipated due to a minimal amount of source chemical remaining in a tanker car (for example), and the release has ended as quickly as it started.

i. Block 10

A properly trained hazardous materials team or incident commander begins the process of issuing a shelter-in-place directive to the public based on the IMAAC plume prediction. The hazmat team or incident commander notifies dispatch to immediately issue a shelter-in-place message to the specific area as detailed by the IMAAC plume model prediction.

j. Block 11

A properly trained alerting agency (i.e., dispatch center) will access the IMAAC website and view the plume prediction created by the hazardous materials team or incident commander. A dispatch center has no involvement in creating the plume prediction. A dispatch center simply accesses the IMAAC model created by the on scene experts using IMAAC.

k. Block 12

A properly trained alerting agency (i.e., dispatch center) uses the alerting mechanisms available to notify the public of the need to shelter in place based on the tools or systems available to a jurisdiction. Some jurisdictions have access to notification software where very similar (accurate) shape and dimensions of the IMAAC plume prediction can be transposed into a system that will automatically make landline telephone, cellular telephone, email, or text message notification to those contact numbers located within the IMAAC plume model shape electronically "drawn" on a system alert GIS map. Since no model is exact, the dispatch center using this type of software has flexibility to expand the plume dimensions to ensure that borderline addresses receive the same notification as those more directly in the path of the plume. There are several alerting variations inherent in Block 12 that would be addressed through IMAAC procedures, training, and exercises as generally discussed with Figure 5.

l. Block 13

The incident commander makes a request for EOC activation.

3. Figure 3

Figure 3 is a representation of on an IMAAC stand alone model that becomes necessary in case Web-based internet access to IMAAC is not available. OFM 3 is designed to provide jurisdictions an alternative to create plume predictions in cases where internet access may be significantly delayed or out of service. There are many similarities to OFM 2; however, some coordination and logistics regarding OFM 3 decision points are very jurisdiction-dependent.

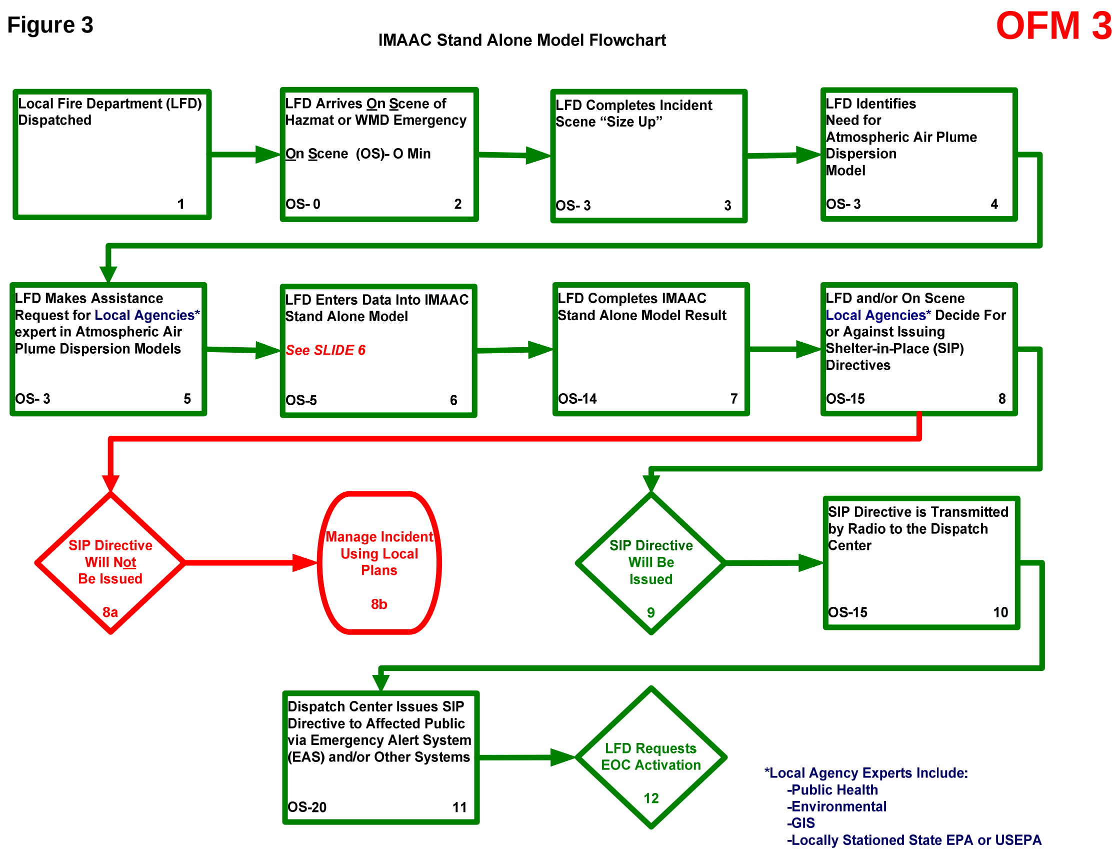

Figure 3. IMAAC-Local Jurisdictions WMD Hazardous Materials Operations Framework Stand Alone Model Flowchart

a. Block 1

Most incidents are reported to a dispatch center (i.e., 911 call centers) and the proper units are dispatched to an incident scene based on departmental dispatch

protocol. The incident description provided by a caller is wholly subjective and will dictate the units dispatched to mitigate such an incident. Due to variations in jurisdiction protocol and potential for other uncontrollable incident reporting variables, the 20-minute mark for shelter-in-place initiation does not begin with the dispatch of units typically assigned for response to a hazardous materials or weapons of mass destruction incident.

b. Block 2

The time clock for OFM 3 begins with the arrival on scene of the hazardous materials team or properly trained/equipped incident commander. Because response times will vary for jurisdictions largely dependent on the proximity of incident location to the units dispatched, the time clock for OFM 3 does not begin until scene arrival by the respective units. **Note:** the notation “OS” stands for “On Scene” and all times are represented by (OS) minus (the minutes from scene arrival). OS–0 starts the clock. Times in subsequent blocks are represented by the same type of notation.

c. Blocks 3, 4, and 5

The incident commander is gathering and processing relevant incident information in the first three minutes of on-scene arrival. During this timeframe, a properly trained incident commander or hazardous materials team can have acquired enough information in order to reach a conclusion that atmospheric air plume dispersion modeling will be useful in helping manage short-term and long-term consequences associated with the respective incident. **Note:** In the first three minutes, the hazardous materials team or incident commander shall request assistance from locally positioned support agencies, such as global information systems (GIS), law enforcement, public health, and local, state, and federal environmental protection agencies.

d. Block 6

A properly trained hazardous materials team or incident commander accesses the IMAAC stand alone model and enters the required information into the model in five minutes or less.

e. Block 7

A properly trained hazardous materials team or incident commander will have created an IMAAC stand alone plume model prediction in 14 minutes or less from the time of arrival on scene. The plume model prediction is generated by IMAAC software that permanently resides on the hazardous materials team or incident commander stand alone computer and/or mobile data computer (MDC). It is not necessary to access the IMAAC website for OFM 3.

f. Block 8

Based on the plume model result and additional scene information acquired while waiting for the plume prediction to be calculated and returned by IMAAC, a properly trained hazardous materials team or incident commander could reach a decision to issue a shelter-in-place directive to the effected population. This decision would be made according to jurisdiction protocol and in collaboration with other local agencies that may have arrived on scene or established contact with the incident scene after receiving a request for assistance as previously described in Block 5.

g. Block 8a and 8b

Further information could lead to a decision to forgo a shelter-in-place directive. For example, maybe a non-hazardous release was misidentified "as a hazard" and additional information obtained has effectively ruled out a hazard; or maybe the plume has almost completely dissipated due to a minimal amount of source chemical remaining in a tanker car (for example), and the release ended as quickly as it started.

h. Block 9

A properly trained hazardous materials team or incident commander begins the process of issuing a shelter-in-place directive to the public based on the IMAAC stand alone model plume prediction. The hazmat team or IC notifies dispatch to immediately issue a shelter-in-place message to the specific area as detailed by the IMAAC plume model prediction.

i. Block 10

A properly trained alerting agency (i.e., dispatch center) will receive and view the plume prediction created by the hazardous materials team or incident commander. A dispatch center has no involvement in creating the plume prediction. A dispatch center will receive the plume prediction by email, fax, etc., or by the most efficient means available to a respective jurisdiction.

j. Block 11

A properly trained alerting agency (i.e., dispatch center) uses the alerting tools available to notify the public of the need to shelter in place based on the tools or systems available to a jurisdiction. Some jurisdictions have access to notification software where very similar (accurate) shape and dimensions of the IMAAC plume prediction can be transposed into a system that will automatically make landline telephone, cellular telephone, email, [or, and or?] text message notification to those contact numbers located within the IMAAC plume model shape electronically "drawn" on a system alert GIS map. Since no model is exact, the dispatch center using this type of software has flexibility to expand the plume dimensions to ensure that borderline addresses receive the same notification as those more directly in the path of the plume. There are several alerting variations inherent in Block 11 that would be addressed through IMAAC procedures, training, and exercises as generally discussed with Figure 5.

k. Block 12

The incident commander makes a request for EOC activation.

4. Figure 4

Figure 4 is a representation of how support staff assigned to Lawrence Livermore National Laboratories National Atmospheric Release Advisory Center, which has been designated by the Department of Homeland Security as the interim host for IMAAC would directly support local jurisdictions after approximately the first hour on an incident scene requiring atmospheric air plume dispersion modeling assistance.

Figure 4

OFM 4

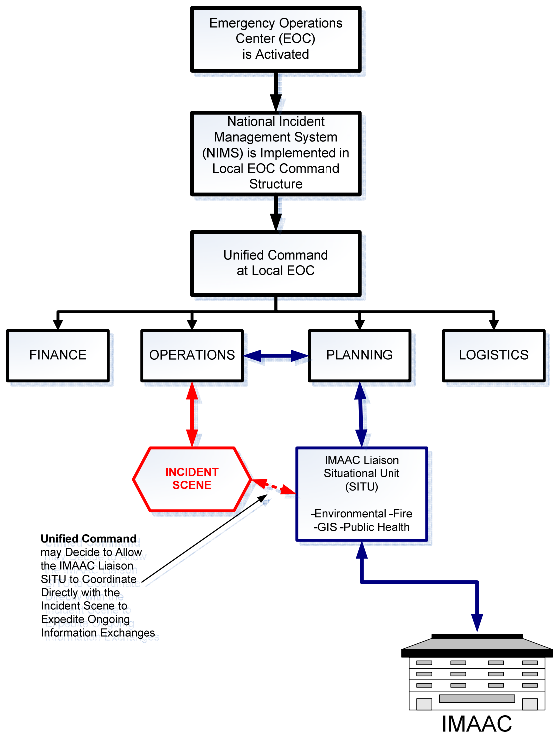

Figure 4. IMAAC-Local Jurisdiction WMD Hazardous Materials Operations Framework National Incident Management System and Unified Command Structure Model

OFM 4 begins with local jurisdiction EOC activation with immediate implementation of the National Incident Management System (NIMS) to assist with an incident of extended duration. OFM 4 depicts a traditional incident command structure illustrating the lines of communication and information flow between on scene operations, Unified Command, and "reach back" support from IMAAC staff.

IMAAC represents IMAAC support staff presently based at NARAC. The IMAAC Liaison Situational Unit (SITU) represents a locally situated advisory unit to the Planning Section organized to address ongoing coordination issues regarding atmospheric air plume dispersion modeling in the context of a specific incident. The SITU could be a pre-identified group of people, or the SITU could be a fluid body largely incident-dependent and contingent on subject matter expert availability at the time of an incident.

By design, the incident scene command structure would communicate information to Unified Command Operations Section Chief in this illustration functioning out of an EOC. The Unified Command Operations Section would keep Command informed and relay information to the Planning Section that would in turn push the information down to the local IMAAC SITU also functioning from the same EOC location as Unified Command. The local IMAAC SITU would then communicate directly with the IMAAC reach back support staff stationed at IMAAC in Livermore, California. Information would then flow inversely through the same pathways ensuring that Unified Command was fully apprised of situational updates throughout incident duration. Unified Command, including the Operations and Planning Section Chiefs, will remain fully-apprised with accurate situational awareness by following a NIMS-type structure.

The representation depicting the local IMAAC SITU communicating directly with the incident scene could be advisable if scientific information necessary to effect plume model calculations was being lost in translation for example. If this type of communication was approved by Unified Command and the respective Section Chiefs, it is mandatory that Unified Command maintain comprehensive situational awareness with respect to plume modeling as such models will likely drive many aspects of the response and recovery mission as related to a particular incident.

5. Figure 5

Figure 5 does not address incident scene management aspects similarly to Figures 1, 2, 3, and 4. Figure 5 is representative of the building blocks necessary for many of the objectives represented throughout Figures 1, 2, 3, and 4. Procedures, training, exercises, and funding possibilities are the basis for OFM 5 addressing key issues identified in GAO–08–180.

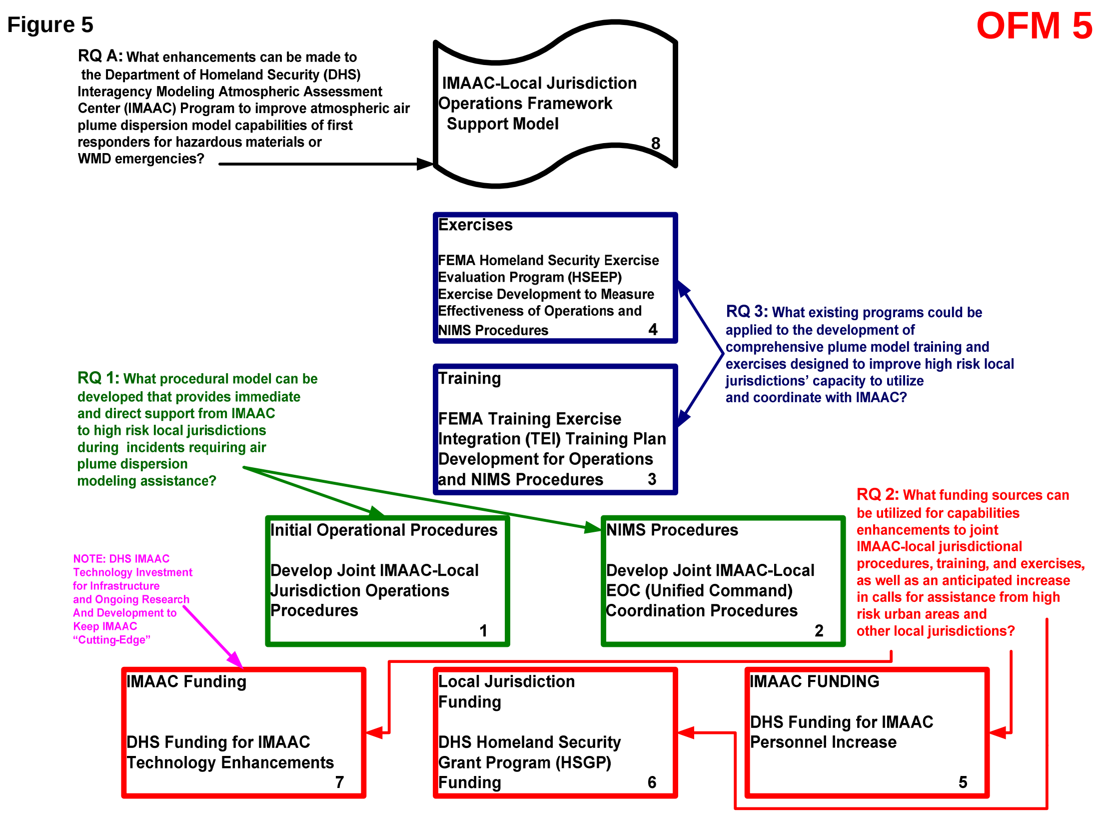

Figure 5. IMAAC-Local Jurisdiction WMD Hazardous Materials Operations Framework Support Model

a. *Blocks 1 and 2*

Aspects of these blocks are addressed by OFM 2 and OFM 3 specifically from a local jurisdictional perspective. OFM 4 addresses details for ongoing coordination between IMAAC and a local Unified Command for air plume modeling incidents of extended duration.

b. *Blocks 3 and 4*

These blocks identify training and exercise programs currently used by DHS (FEMA) and have particular relevance to emergency responder disciplines that may become involved in incidents requiring atmospheric air plume dispersion modeling. These blocks elicited much discussion throughout the interview research process.

c. Block 6

Block 6 addresses a potential funding source for development and execution of local jurisdictions' procedures, training, and exercises in the context of IMAAC. Homeland Security Grant Program funding was addressed with respective interviewees since the cities interviewed receive HSGP funding.

d. Blocks 5 and 7

This thesis does not address funding sources for enhancements which may be necessary for IMAAC. It is assumed that increases in support services will come at a cost to IMAAC. Funding sources that could be used for local jurisdictions would not be the same for federal agencies such as IMAAC. Local jurisdictions would synergize HSGP funds which make Blocks 1, 2, 3, and 4 relatively cost neutral and which would be addressed by Block 6. Additional funds to adequately increase IMAAC capacity would have to come from DHS and IMAAC-partner agencies. Blocks 5 and 7 were not addressed with the interviewees.

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IV. METHODOLOGY

A. INTRODUCTION

The two methodologies selected for this thesis were the qualitative analysis of existing literature and the qualitative analysis of interview data from seven selected interview subjects (described below). A qualitative analysis of the existing literature was necessary to help identify key issues still prevalent six years after the inception of IMAAC. The literature provided the rationale and much of the basis for development of framework model components designed to address outstanding IMAAC issues. A qualitative analysis of data derived from interview subjects provided both affirmation and ideas for revisions that could result in an overall more effective framework model. Interviews of IMAAC and similar air plume model system users provided evidence of issues that sill exist as identified through the qualitative analysis of the literature. Interviews also supplied additional insights into ongoing IMAAC issues not as clearly defined by the existing IMAAC literature. The combination of literature and interview qualitative analysis was foundational both in development and affirmation of the proposed operations framework model.

B. QUALITATIVE ANALYSIS OF THE LITERATURE

Atmospheric air plume dispersion modeling can be crucial to public safety during certain hazardous materials incidents (Borysiewicz et al., 2006); therefore existing literature was researched to assist with the development of an atmospheric air plume dispersion modeling operations framework. As a result, a framework model was developed to address the role that IMAAC and local jurisdictions fulfill providing for the public safety during an accidental or intentional spill, release, or discharge of a WMD or hazardous material into the environment. The model developed, as a result of the research, is referred to as the Local Jurisdiction-IMAAC Operations Framework Model.

Memoirs from former Department of Homeland Security Secretaries Tom Ridge and Michael Chertoff warn of a relentless adversary willing to use CBRNE weapons on

democratic nations, especially the United States. In a 2010 study released by the Belfer Center for Science and International Affairs, Harvard College, Larssen (2010) affirms that terrorist organizations remain intent on killing Americans by any means available, and a compelling incident timeline is formulated detailing a dogged pursuit of chemical, biological, and nuclear weapons by Al Qaeda and other Islamism extremist sects. There is testimony before Congress of at least one official summarizing that during a chemical release large numbers of people actually move in the direction of the hazard due to an inability of many response agencies to create and apply accurate plume predictions (U.S. Senate Hearing 109-62, 2005).

These types of literature examples amplified an ongoing risk to the public affirming the need for an enhanced national IMAAC type of capability as represented by the proposed framework model. Because of a plethora of literature describing hazardous materials accidents as well as the potential for CBRNE incidents, the Operations Framework Model was developed to improve upon the current deficient coordination between IMAAC and most local jurisdictions regarding planning and response for emergencies requiring atmospheric air plume dispersion modeling.

The literature analyzed for use in model framework composition was divided into five basic categories:

1. Hazardous materials incident after action reports and case studies
2. U.S. government publications, directives, and other similar documents
3. DHS programs for grants, training, and exercises
4. IMAAC, Local Integration of NARAC to Cities, and the Ohio LINC Response System (ORS) Pilot Program
5. Evacuation and shelter-in-place literature

The research methodology used was the qualitative analysis of literature focused on subject matter directly or indirectly related to IMAAC. Literature affirming the importance of plume modeling was reviewed in the form of case studies and incident overviews describing global hazardous materials accidents and some CBRNE incidents. Research also focused on the qualitative analysis of existing Interagency Modeling

Atmospheric Assessment Center literature necessary to comprehend the present operational paradigm of the Center especially as related to local jurisdictions. For example, Homeland Security Presidential Directive 8 emphasizes the importance of local-federal incident collaboration, which is also identified as a key IMAAC deficiency by GAO–08–180. In addition, several TOPOFF documents were analyzed which identified key weaknesses in national atmospheric air plume dispersion modeling capabilities for local, state, and federal stakeholders. TOPOFF literature identified shortcomings in current practices with atmospheric air plume dispersion modeling both before and after IMAAC implementation.

Moreover, FEMA training and exercise literature was reviewed and added insights into adequately addressing air plume model issues at all operational levels. FEMA training and exercise literature in particular was selected because this would allow for an exceptionally quick impact in plume modeling training/exercise areas by minimizing delays in respective program development. Furthermore, such FEMA programs allow for DHS grant funds to be used for approved training/exercise development and execution. Homeland security grant funds literature provided information that could help address funding questions for the many elements required to create an enhanced national capability for atmospheric air plume dispersion modeling.

Other information reviewed included the Local Integration of NARAC to Cities pilot program, which was designed to bring NARAC support directly to select cities during emergencies and bearing many similarities to IMAAC.[16] LINC city representatives were trained in use of the NARAC system. The researcher was the lead for the City of Cincinnati with the LINC project as one of five United States LINC cities.[17] This case study and the author's organizational experience with the Ohio LINC Response System[18] were also evaluated. Experiences and lessons learned attributable to

[16] Lawrence Livermore National Laboratories (LLNL) NARAC is the current interim host of IMAAC. Today, when jurisdictions or agencies are approved to receive IMAAC assistance, they are communicating with LLNL NARAC in a very similar manner which was utilized during the LINC Pilot Program.

[17] Albuquerque, NM; Cincinnati, OH; Ft. Worth, TX; New York, NY; and Seattle, WA were selected as LINC pilot cities resultant much from affiliation with the Public Technologies Institute (PTI), Inc.

[18] The Ohio LINC Response System was similar in design and operation to LINC and included the Ohio cities of Akron, Cincinnati, Cleveland, Columbus, Dayton, and Toledo.

literature describing these programs provided many insights for OFM development. Finally, qualitative analysis of evacuation and shelter-in-place (SIP) literature describing potential air plume model public protective actions provided the value inherent in the entire thesis project.

C. QUALITATIVE ANALYSIS OF INTERVIEW DATA

The qualitative analysis of interview data from NARAC[19] system users was also used to evaluate the proposed Operations Framework Model. Users were chosen from the fire departments directly involved in the aforementioned LINC and Ohio LINC programs. Ohio LINC interviewees had performed key organizational and/or operational roles within their jurisdictions for respective program implementation and dissemination. Cincinnati was the only city involved in both programs.

As part of the research, efforts were made to conduct telephone interviews with cities involved in the Ohio LINC program. However, due to the complexity of the model (Chapter III) telephone interviews were quickly ruled out as a viable means by which to obtain data. Based on the first phone interview attempt, the author discovered high levels of equivocality in terms of understanding the purpose and function of the proposed Operations Framework Model. Upon discovering high levels of equivocality, the researcher shifted from phone interviews to face-to-face interviews, which are higher in media richness to facilitate reducing equivocality while also optimizing feedback on the proposed model (Daft & Lengel, 1986). All six Ohio LINC Cities were interviewed face-to-face providing the basis for the research evaluating varying aspects of the proposed Operations Framework Model.

Ten Department of Homeland Security Urban Area Security Initiative city fire departments were contacted by telephone, none of which had knowledge or familiarity with the IMAAC system. The only UASI fire departments contacted that were familiar with IMAAC were those involved in TOPOFF Exercises, LINC, or the Ohio LINC programs. Cincinnati, Cleveland, Columbus, and Toledo are Urban Area Security

[19] Familiarity with the NARAC system equates familiarity with the IMAAC system with NARAC, which serves as the interim host for IMAAC.

Initiative “high risk” cities as defined by DHS, and as such were included in the Ohio LINC Program. Akron, Cincinnati, Cleveland, Columbus, Dayton, and Toledo are six cities identified by DHS as Metropolitan Medical Response System (MMRS) cities. MMRS cities were originally designated by the Department of Justice (DOJ) as “high risk” cities and DHS continues funding the MMRS Program up to and including fiscal year 2010. Akron and Dayton were included into the Ohio LINC Program based on their original designation by DOJ (and currently with DHS) as MMRS cities. **Note:** Cincinnati is the only city directly involved with the UASI, MMRS, LINC, and the Ohio LINC programs.

Urban Area Security Initiative, Metropolitan Medical Response System, Local Integration of NARAC to Cities, and Ohio LINC were used as criteria for the six cities interviewed for this research.

Table 1. Ohio Cities using the National Atmospheric Release Advisory Center

UASI	**MMRS**	**LINC**	**Ohio LINC**
Cincinnati	Akron	Cincinnati	Akron
Cleveland	Cincinnati		Cincinnati
Columbus	Cleveland		Cleveland
Toledo	Columbus		Columbus
	Dayton		Dayton
	Toledo		Toledo

Below is a brief summary of Table 1:

1. Four cities interviewed are designated as Department of Homeland Security UASI cities

2. All six cities interviewed are designated as DHS MMRS cities

3. One city interviewed was a participant in the LINC Pilot Program

4. All six interviewees were participants in the Ohio LINC Program

No interviews were conducted by telephone. Seven interviews took place in person. Dayton requested that two fire officers be interviewed since both had knowledge in different areas as related to Ohio LINC and MMRS. All interviews were audio

recorded with interview answers transcribed at the researcher's office as previously noted in the IRB documents submitted to the Naval Postgraduate School.

D. DATA COLLECTION

The interviews took place at a date, time, and location agreed upon between the interviewer and interviewee. The interviews were conducted in person in the Ohio cities of Akron, Cincinnati, Cleveland, Columbus, Dayton, and Toledo. The interviewee was provided a copy of the proposed Operations Framework Model. In addition, the interviewee was given time to review the framework model (Chapter III) for familiarity.

The following research questions were then asked referencing each of the Operations Framework Model sections including OFM 1, 2, 3, 4, and 5 (Chapter III):

1. What enhancements can be made to the Department of Homeland Security (DHS) Interagency Modeling Atmospheric Assessment Center Program to improve atmospheric air plume dispersion model capabilities of first responders for hazardous materials or WMD emergencies?

2. What procedural model can be developed that provides immediate and direct support from IMAAC to high risk local jurisdictions during incidents requiring atmospheric air plume dispersion modeling assistance?

3. What funding sources can be utilized for capabilities enhancements to joint IMAAC-local jurisdictional procedures, training, and exercises, as well as an anticipated increase in calls for assistance from high risk urban areas and other local jurisdictions?

4. What existing programs could be applied to the development of comprehensive plume model training and exercises designed to improve high risk local jurisdictions' capacity to utilize and coordinate with IMAAC?

The proposed Operations Framework Model (Chapter III) is made up of five sections labeled OFM 1, OFM 2, OFM 3, OFM 4, and OFM 5. All of the interviewees were given time to familiarize themselves with a respective model section prior to discussion of each section. Sections were discussed one at a time and in the context of the research questions.

The interview data varied dependent on which areas of the OFM the interviewee had particular interest or had acquired additional knowledge since the last time NARAC had been utilized by a respective city. The interviewees' answers were audio recorded and later transcribed as related to each model section. For example, as Akron Fire Department answered questions and commented about OFM 1, those comments were transcribed in the section following OFM 1 (Chapter V). The interviews then addressed OFM 2, OFM 3, OFM 4, and OFM 5 in a linear manner with comments recorded from each city relative to each section of the proposed Operations Framework Model.

E. DATA ANALYSIS

1. Analysis of the Literature

An analysis of the relevant characteristics of disasters was germane to how the proposed models could be used for assistance with planning, response, and initiating public protective actions. A qualitative analysis of this information helped with the visualization and formulation of the proposed Operations Framework Model. Some supposition was applicable in the context of incident-specific literature; for example, the possibility that an incident *similar to* the Graniteville, South Carolina chlorine railcar derailment could just as easily have occurred in a more densely populated urban area.

As referenced earlier, Homeland Security Presidential Directive 8 emphasizes the importance of local-federal incident collaboration which was identified as a key IMAAC deficiency by GAO–08–180. This deficiency is addressed by certain proposed model elements in the OFM. With respect to overall coordination of all incidents, HSPD 5 mandates the implementation of the National Incident Management System and provides much of the basis for the joint IMAAC-local jurisdiction procedure development components found in the OFM.

Documents from TOPOFF 2, TOPOFF 3, and TOPOFF 4 were reviewed for key areas on which to focus in formulation of an IMAAC-Local Jurisdiction Operations Framework Model. For example, the difficulty for most first responders in accurately interpreting and applying plume data was a recurrent challenge experienced during

TOPOFF exercises, which is addressed by a training element incorporated into the OFM. Literature describing the Federal Emergency Management Agency Training Exercise and Integration Program, and the FEMA Homeland Security Exercise Evaluation Program (HSEEP) became the primary basis for the formulation of related OFM components. Utilization of the DHS FEMA Training Exercise Integration and Homeland Security Exercise Evaluation Program (See Figure 5, Blocks 3 and 4) would minimize delays for approval to use grant funds for training and exercise development which could help expedite proposed local and IMAAC system enhancements. DHS Homeland Security Grant Program literature (see Figure 5, Block 6) was also evaluated in the context of overall fiscal support for model development as well as implementation of the procedure, training, and exercise components of the Operations Framework Model (Chapter III).

Other information detailed the Local Integration of NARAC to Cities pilot program which was designed to bring NARAC support directly to designated cities and bearing many similarities to IMAAC. The researcher was the lead for Cincinnati with the LINC project as one of five LINC cities selected nationwide. Similarly to the LINC program, the Ohio LINC Response System was originally envisioned as an element of the Ohio Response System.[20] Ohio LINC teams were organized in six MMRS cities[21] throughout Ohio. The Ohio LINC pilot program was discontinued due to a lack of resources necessary for ongoing organization, training, and exercise activities. The Ohio cities maintain NARAC access; however, the Ohio LINC program is no loner in operation. Lessons learned throughout both of these initiatives provided much of the basis for OFM development. Finally, a qualitative analysis of evacuation and shelter-in-place literature was used to affirm model objectives in the form of public protective actions that if necessary the OFM was designed to effect.

[20] The ORS is an automatic mutual aid system within the state of Ohio that identifies pre-defined resources available for statewide mutual aid if so requested.

[21] The six cities selected had been previously designated by the Department of Justice (DOJ) as Metropolitan Medical Response System (MMRS) cities. There are 124 MMRS cities nationwide, and DHS continues to fund the MMRS program through 2010. (MMRS, 2005).

2. Analysis of Interview Data

The data collected from each interview was grouped by each fire department interviewee as related to the respective section of the proposed Operations Framework Model for the purposes of categorizing the interview data. The individual respondent has been identified by city fire department and by position within the department as was agreed upon with the interviewee prior to conducting the interview.

In addition, a proposed model (IMAAC-Local Jurisdiction WMD/Hazardous Materials Operations Framework Model) or OFM was presented as a visual representation of actions and decision benchmarks that would potentially be undertaken by a local fire department on the scene of a hazardous materials or weapons of mass destruction emergency. These actions and decision benchmarks were highlighted and discussed during the interview process with the interviewee providing affirmation, objection, neutrality, or adjustment to the respective action or benchmark.

As a result of the data collected from the interview process, an inductive qualitative analysis was conducted to validate the proposed model and to identify gaps or possible extensions in the IMAAC-Local Jurisdiction WMD/Hazardous Materials Operations Framework Model. Based on the interview data, analysis, and conclusions, recommendations were formulated on the development of model enhancements that were integrated as OFM revisions into an OFM hybrid framework model. This validation process formed the basis for model findings and recommendations in Chapter VI.

Due to the fact that the researcher is currently a Cincinnati Fire Department District Fire Chief and active user of the National Atmospheric Release Advisory Center system, this study was conducted in efforts to limit any personal or professional biases, by including officials from cities of greater, similar, and lesser populations that correlated to respective fire department call volume, organizational size, and management structure. Prior experience and knowledge of NARAC (IMAAC) from a fire department perspective was also a prerequisite for an interview as attempts to gather data from fire department officers possessing no knowledge of NARAC (IMAAC) proved

unproductive. Understandably, such fire officers were unable to provide perspective on the IMAAC system in the context of the proposed model due to unfamiliarity with the IMAAC system.

Fire department officials interviewed included line, command, and planning officers. The line officers interviewed are positioned to make decisions and take actions such as those represented by the model. Similarly, the command and planning officers interviewed are responsible for hazardous materials and weapons of mass destruction planning within a department at an operational and strategic level. All of the interviewees would shoulder elements of responsibility for actions and decision points as represented in the Operations Framework Model. As such, the OFM interview process remained consistent by presenting the same model and questions in the above prescribed order to gather data, validate, and extend the proposed model, culminating in findings and recommendations as described in Chapter VI.

V. DATA COLLECTION

A. INTERVIEWEE DESCRIPTION

Fire department representatives from six Ohio cities were selected to be interviewed. The cities were selected based on their inclusion by the Department of Homeland Security into either the DHS Metropolitan Medical Response System (MMRS) or Urban Area Security Initiative (UASI) Homeland Security Grant Programs (HSGP).

Interviews were conducted with the appropriate atmospheric air plume dispersion model experts from Ohio UASI or MMRS fire departments and with responsibility and knowledge of plume modeling. The fire department personnel interviewed were very familiar with NARAC (IMAAC), particularly through the implementation of the 2004 Ohio LINC[22] Response System. The Ohio LINC system was composed of the six Ohio cities which were included by DHS in either one or both of the UASI and MMRS Programs.[23].

Table 2. Ohio Cities Interviewed for This Research

Akron	MMRS
Cincinnati	MMRS and UASI
Cleveland	MMRS and UASI
Columbus	MMRS and UASI

[22] The atmospheric air plume dispersion modeling system used throughout the LINC Program is very similar to the IMAAC plume modeling program presently in operation. LINC cities maintain direct access to the NARAC plume modeling program which again is very similar to the IMAAC plume modeling program presently hosted by NARAC.

[23] MMRS cities were originally designated by the Department of Justice (DOJ) based on Metropolitan Statistical Areas (MSAs) with the greatest number of population. The MMRS program was transferred from DOJ to DHHS to eventually DHS in 2002–2003 and MMRS grant funding has continued annually since fiscal year (DY) 2005 up to and including FY 2010. (MMRS, 2005) The DHS Urban Area Security Initiative Program has also been funded annually by DHS beginning in FY 2003 up to and including FY 2010. UASI cities are selected by DHS based on their vital role in providing for the security of the United States homeland (DHS, 2003).

Dayton	MMRS
Toledo	MMRS and UASI

Table 3. Representatives from Ohio UASI and/or MMRS City Fire Departments

Akron	Fire Department Special Operations Unit Captain
Cincinnati	Fire Department Hazardous Materials Unit District Chief
Cleveland	Fire Department WMD Coordinator
Columbus	Fire Department Hazardous Materials Unit Captain
Dayton	Fire Department (former) MMRS Captain Fire Department (former) MMRS Lieutenant[24]
Toledo	Fire Department Special Operations Bureau Captain

An interview was attempted by phone and became too complicated for the researcher and the interviewee. Interview feedback during the phone interview was limited, and there was substantial confusion regarding interview coordination and overall subject matter. Therefore, interviews were performed in person in each of the respective cities at the interviewees' place of assignment. Interviewees were provided five slides previously detailed in the Chapter III Models Section and also listed below. In Chapter III, elements of these slides were mapped to the following research questions:

1. What enhancements can be made to the Department of Homeland Security (DHS) Interagency Modeling Atmospheric Assessment Center Program to improve atmospheric air plume dispersion model capabilities of first responders for hazardous materials or WMD emergencies?

2. What procedural model can be developed that provides immediate and direct support from IMAAC to high risk local jurisdictions during incidents requiring air plume dispersion modeling assistance?

3. What funding sources can be utilized for capabilities enhancements to joint IMAAC-local jurisdictional procedures, training, and exercises, as well as an anticipated increase in calls for assistance from high risk urban areas and other local jurisdictions?

[24] The Captain and Lieutenant were responsible for MMRS at the time of the Ohio LINC System Pilot Program. The Lieutenant has been identified as the most knowledgeable department member regarding IMAAC for the Dayton Fire Department.

4. What existing programs could be applied to the development of comprehensive plume model training and exercises designed to improve high risk local jurisdictions' capacity to utilize and coordinate with IMAAC?

Interviews occurred in the context of the research questions, which also led to other more detailed discussion. During the course of the interviews respondents were particularly interested in the claims made in Figure 2, Figure 3, and Figure 5; this provided much of the basis for ongoing discussions regarding IMAAC findings and recommendations in Chapter VI. All interviews were audio recorded and transcribed at a later date.

B. INTERVIEW DESCRIPTION

The following chapter is organized with each section beginning with a figure previously detailed in the Chapter III Model Section. Interviews took place in the context of the research questions, the proposed model, and the discussion that was generated after reviewing each step of the respective models in detail. The summations with respect to a specific model are provided according to each city. Several conclusions were either affirmed or adjusted based the interviews. Some recommendations were based on discussion spurred by reaction to model claims and ensuing discussion points. Seven interviews were conducted in total. All agencies interviewed maintain access and still use NARAC (IMAAC) for emergencies, planning, training, or exercises.

Finally, when reading Chapter V and Chapter VI, the reader should view IMAAC and NARAC synonymously. This is based on the fact that NARAC currently serves as the interim host for IMAAC in partnership with the eight federal agencies listed in Chapter I. The cities interviewed do not have IMAAC access, but the do have NARAC access. The underlying assumption in Chapter V and Chapter VI is that NARAC and IMAAC have similar requirements and capabilities. This assumption is based on ongoing professional (informal) association with LLNL (NARAC). Furthermore, if there are differences, it is the author's claim that it is reasonable to assume that IMAAC would in fact be "superior" to NARAC which makes the interview data collected reference NARAC even more remarkable.

C. INTERVIEWS

1. IMAAC-Local Jurisdiction WMD Hazardous Materials Operations Framework (Figure 1)

Figure 1 was designed to provide the interviewee with an overall context from which to discuss the proposed framework model. Figure 1 was useful with providing a wide-angle lens through which to view IMAAC relative to incidents potentially requiring atmospheric air plume dispersion modeling.

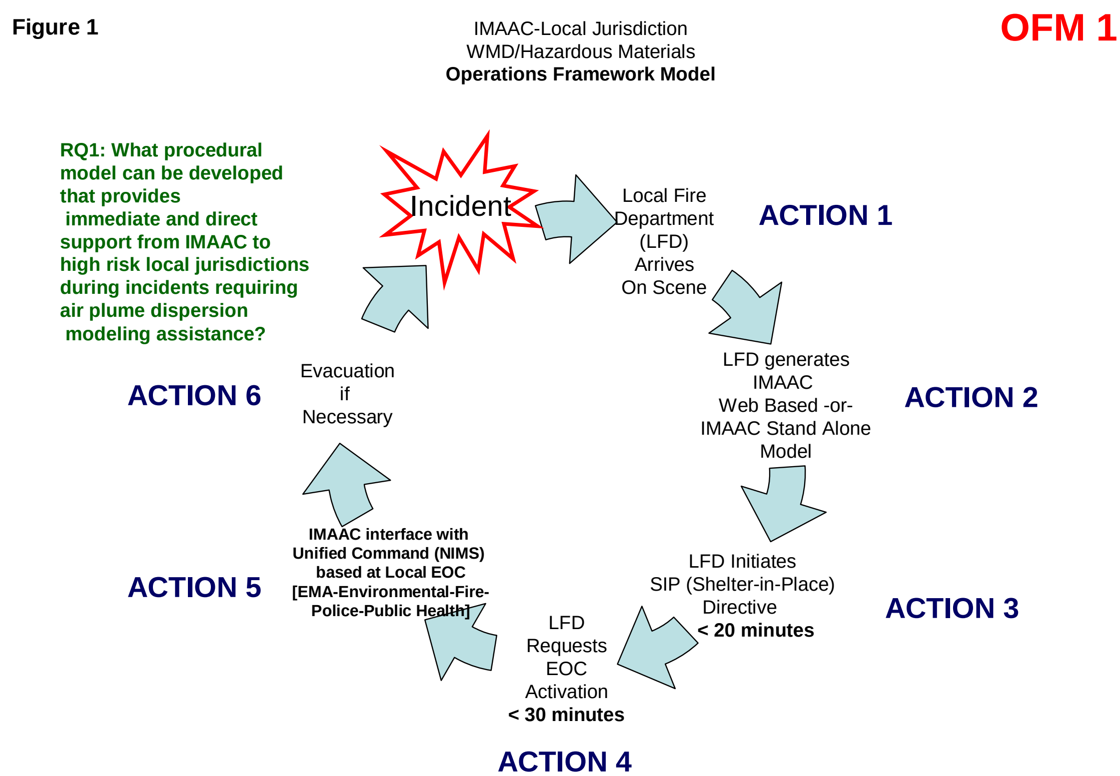

Figure 1. IMAAC-Local Jurisdiction WMD Hazardous Materials Operations Framework Model 1

a. Akron

The Akron Fire Department (AFD) engaged in general discussion on this model element expressing some reservations regarding inherent differences between a

Web-based versus a stand alone model. AFD added additional comments as the interview progressed into analysis of the specific theoretical framework model claims and recommendations.

b. Cincinnati

Cincinnati Fire Department (CIN FD) commented that Figure 1, Action 2 was realistic and with respect to local departmental operations procedures. CIN FD added that because of some inherent delays in receiving assistance from outside agencies that it could become extremely important to disseminate shelter-in-place direction quickly (less than 20 minutes) because of the risk to public health and safety whether from weapons of mass destruction or hazardous materials incidents. Delays in receiving assistance from mutual aid agencies may be unacceptable depending upon the type and quantity of material released. If it becomes necessary, a local fire department should be able to make a shelter-in-place decision independent of other agency assistance. CIN FD acknowledged that it would be preferable to have assistance from other agencies while making such a decision; however, such assistance may not always be available in a timely fashion.

c. Cleveland

Cleveland Fire Department (CLE FD) questioned the distinction between SIP and evacuation. For people who can self-evacuate, self-evacuation may make sense and those capable of self-evacuating may benefit from doing so early in the incident versus a sheltering in place. CLE FD also questioned the length of the SIP and if that was part of the model. CLE FD had general questions about Action 3 which were discussed in more detail later in the interview.

d. Columbus

Columbus Fire Department (COL FD) correlated this scenario to an incident that recently took place in Columbus bearing some similarities to that incident. COL FD understood the scenario as presented and elected to withhold detailed comment until later in the interview.

e. Dayton

Dayton Fire Department (DFD) personnel had initial questions about the 20-minute mark "shelter-in-place directive" as described in Figure 1, Action 3. DFD was generally agreeable with the timeline as described in the model but expressed initial reservations dependent upon subsequent information discussed during this interview.

f. Toledo

Toledo Fire Department (TFD) was agreeable to the timeframe expressed in this model including issuing shelter-in-place directives in 20 minutes or less as long as the incident source is readily identifiable. If there was a universally acceptable source term that could be safely utilized for incidents involving unknown sources then the modeling process could continue with minimal delays. If there are delays in plume modeling due to source term confusion, all times would likely be negatively delayed awaiting source identification. Finally, TFD expressed concern that they will continue to have access to NARAC similar to their experience with the Ohio LINC Response System.

Note: With respect to concerns addressed by TFD, it is not the purpose of this thesis to argue what source terms for unknowns are better than others for incidents where the source is unknown or especially difficult to identify. That is an issue that could best be addressed by IMAAC partner agencies and reviewed with operators during training. Additional training need is frequently referenced throughout this chapter and Chapter VI.

2. IMAAC-Local Jurisdiction WMD Hazardous Materials Operations Framework Web-based Model Flowchart (Figure 2)

Figure 2 was designed to break down key points beginning with incident on scene arrival up to and including transmitting a shelter-in-place order to the affected population. Breaking an incident down into steps helped interviewees to better-focus on key aspects of an incident scene response.

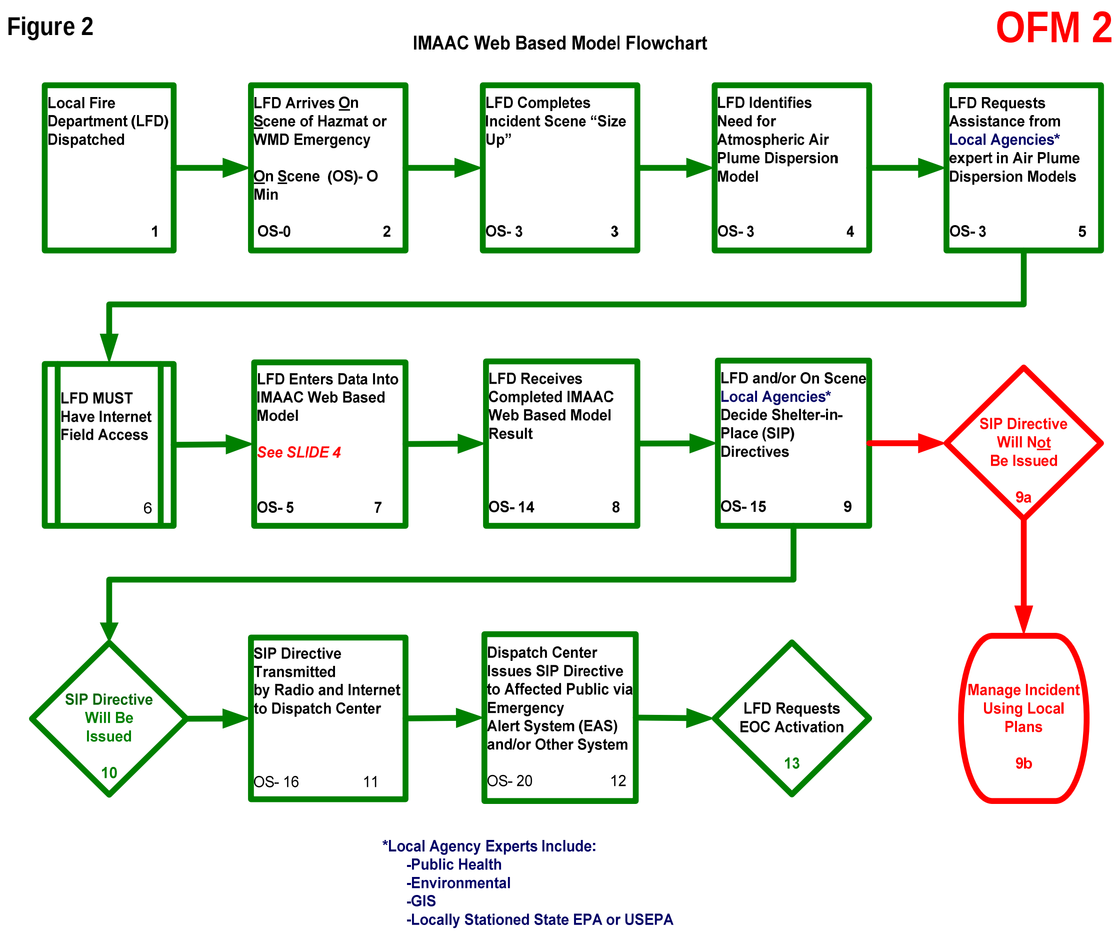

Figure 2. IMAAC-Local Jurisdiction WMD Hazardous Materials Operations Framework Web-based Model Flowchart

a. Akron

AFD concluded that it is reasonable to assume that a trained command officer could accomplish actions in Figure 2, Blocks 3, 4, and 5 in three minutes or less. Because of the ease of use of NARAC, it is reasonable to project basic model data inputs in five minutes or less as described in Figure 2, Block 7. Even though incident commanders (ICs) are not necessarily trained as hazardous materials technicians, they could be trained to a proficiency level allowing them to make a shelter-in-place decision relatively easily. However, if ICs do not have adequate knowledge or training, they will have little choice but to rely on someone with adequate training. If ICs were trained properly, ICs could get to a level where they could effectively determine if a SIP action was called for as described in Figure 2, Block 9. AFD stated that an IC "absolutely" could be trained to a level capable of making a SIP decision and also be capable of transmitting a SIP decision in 16 minutes or less as described in Figure 2, Block 11.

Regarding Block 12, dispatch center operators could be trained to access a website (IMAAC) and view a plume model created by AFD on the scene of an emergency. Dispatch would require training and proper IMAAC website access rights, thereby giving AFD dispatch access to the same plume model picture generated on the emergency scene. AFD could then use a reverse 911 type of system that allows for drawing geometrical shapes in the same shape as an IMAAC plume prediction. This would allow for a more accurate and precise notification of the exact population adversely affected. In other words, the geo-coded notification can be drawn very similarly to the shape of the IMAAC plume model. All phone numbers and contact information within the reverse 911 system would be 'notified' with a phone call advising to SIP and based on the geometry drawn (and geographically coded) within the reverse 911 system.

In summary, AFD was optimistic that with proper training and procedures that the SIP notification time represented in Figure 2, Block 12 as well as Figure 1, Action 3 was readily achievable.

b. Cincinnati

CIN FD agreed that the on scene times and corresponding actions in Figure 2, Blocks 3, 4, and 5 were complementary to Figure 1, Action 2, and achievable in the stated time of three minutes or less from arrival on the emergency scene. CIN FD also agreed that based on past experience with NARAC that it is reasonable to expect a completed plume model prediction in the stated time of less than 14 minutes (Figure 2, Block 8). CIN FD commented that NARAC has a historically very quick turnaround with plume model results and as long as there was no delay on the NARAC end, the plume model results could be “in hand” in less than or equal to the time listed in Figure 2, Block 8. CIN FD added that Figure 2, Block 12 would be extremely challenging based on experience with a large hazardous materials fire occurring in Cincinnati in 2004. However, CIN FD concluded that Figure 2, Block 12 would be possible if there was a system that allowed for easy transmission of key information (address, plume vector, message, and message distribution), which could be quickly disseminated to an endangered population.

The value of notifying those in danger versus notifying the entire population during an emergency could also contribute to better utilization of limited resources and would help ensure that the people actually in danger received a shelter in place message as quickly as possible with respect to a limited number of resources (reverse 911 phone lines for example) needed to notify the public of a hazardous materials or WMD emergency. Notifying the entire city as opposed to notification of those in harms’ way could result in delays further contributing to incident management complications. The reverse 911 system recently deployed in Cincinnati would allow for uncomplicated data inputs (incident address, plume vector, message, and message distribution), thus providing a real world example of SIP message distribution to those in danger (versus “everyone”) and in a relatively timely manner. At such time, recipients of the reverse 911 message would be directed to local media for follow up information while they SIP. Those affected could also receive additional reverse 911 messages updating those using SIP and as an incident progressed. Finally, CIN FD concluded that

unless the public does its part and learns how to take effective SIP action, delivering SIP direction would be ineffective no matter how accurate the plume predictions.

c. Cleveland

Regarding Figure 2, Blocks 3, 4, and 5 Cleveland Fire Department agreed that with proper training and procedure that these actions can be completed in three minutes or less. However, definitive identification of the source chemical or WMD agent is important and can be very challenging, which could contribute to delays.

CLE FD offered an alternative to an on-scene incident commander producing a plume prediction as described in Figure 2, Block 7. CLE FD went on to add that an accurate size up including the proper source term, quantity, and location could be transmitted to someone at a remote location, and an IMAAC model could be generated from the same remote location. CLE FD expressed concern that internet access may be limited for the first-arriving fire companies, or that the IC may be pressed with other scene duties, possibly delaying IMAAC implementation. An IMAAC model could be formulated by transmitting the relevant data information necessary for a plume prediction to a remote third party not on the scene of the emergency. In this manner, an IMAAC model could be remotely-formulated ensuring that the time objective of five minutes or less as described in Block 7 was achieved. CLE FD offered that this approach could help an on scene IC who may be overwhelmed by the incident. Even if information required for plume model development was not perfect, plume model development could still reliably proceed. The CLE FD paraphrased Colin Powel by saying, "…if you have 60% of what you need, then move forward…"

Figure 2, Block 8 is a reasonable timeframe to expect to receive a completed IMAAC plume model after web entries. The model typically provides results in less than 10 minutes in practice mode. During an emergency, CLE FD or other jurisdictions would be operating in emergency mode that should guarantee a plume result in less than 14 minutes as projected in Block 8. CLE FD agrees with the model times as long as there is a good idea of the source chemical and quantity, which will remain a challenge for any atmospheric air plume dispersion model, regardless of which one is

used. CLE FD agrees that if provided enough information, issuing a SIP directive in 15 minutes or less, as described in Figure 2, Block 9, is achievable.

CLE FD expressed a need to open the CAMEO-ALOHA-MARPLOT plume modeling system to obtain an estimate of the potential usefulness of the SIP direction. The respective program helps make estimates on the duration effectiveness of SIP activities with respect to variables such as the source, quantity, and concentration, for example. The SIP timeline would be very important to ascertain, but it would not delay initiating a SIP activity as described in Figure 2, Block 9. The CAMEO-ALOHA-MARPLOT information would provide important affirmation as to the effectiveness of the SIP activity for a respective chemical release.

Finally, regarding Figure 2, Block 12, Cleveland is investigating a notification system that may allow contact of the exact telephone numbers that would fall into the path of the plume (described earlier and similarly to that of AFD and CIN FD). This type of capability would give added value to an accurate plume model through a system such as IMAAC. Figure 2, Block 12 could also be more readily achieved if IMAAC access was made available to the dispatch center. Dispatch could then log into the IMAAC system, look at the plume model, and make more accurate notifications to the affected population based on the plume model. Presently, CLE FD has limited NARAC access which is of concern to CLE FD.

d. Columbus

Columbus Fire Department agreed that the time estimates in Figure 2, Blocks 3, 4, and 5 are reasonable and can be accomplished in the first three minutes of an incident scene as long as the source can be identified. COL FD concluded that Figure 2, Block 7 could be accomplished in five minutes or less as long as the necessary source information was available and IMAAC training for an agency or department remained up to speed. COL FD concurs that as theorized in Figure 2, Block 8 and based on experience that the plume model results would easily come back within the stated timeframe of 14 minutes or less. The Figure 2, Block 9 decision point might be somewhat aggressive based on respective incident commanders' experiences and based

on the source chemicals. According to COL FD, Block 9 may be a weak link in the model because of the complexities of some variables inherent in a SIP decision.

Regarding Figure 2, Block 11, dispatch could be trained to log into the IMAAC website to view the atmospheric plume model prediction created on the scene of the emergency by either a COL FD incident commander or a COL FD hazardous materials team. It is possible that COL FD dispatch could be trained to geo-code a plume prediction (quickly) and transmit a reverse 911 message to a potentially affected population in 16 minutes or less as described in Block 11. COL FD concurred that notification of the affected population is very important versus taking a “notify everyone” approach. However, it could be useful in some cases to default to standard SIP and evacuation directions especially in close proximity to incidents (spills, releases, or discharges), which could take place even more quickly than formulating an IMAAC model.

Use of the “instant” and “reasonable” SIP/evacuation recommendations may make sense, as does using and then utilize application of IMAAC predictions to enhance plume predictions. Such “instantaneous” recommendations could be derived from materials such as the Department of Transportation (DOT) Emergency Response Guide (ERG). COL FD added that it is better to apply accurate information as early as possible during an incident in order to get the incident headed in the right direction. This will save time in the long run by minimizing mistakes that might be made based on several variables including faulty plume information.

e. Dayton

The Dayton Fire Department captain emphasized that Blocks 3, 4, and 5 were a reasonable and realistic timeframe. The DFD lieutenant added that DFD protocol may be a little different and other critical actions may be taking place potentially delaying plume modeling decision, but overall, he concurred that the times and actions listed in Blocks 3, 4, and 5 were realistic.

Regarding Figure 2, Block 7 DFD was asked if the relay of information to a remote site that would create the plume predictions would be realistic. The DFD

Lieutenant concluded that it may be difficult to have someone remotely generate a plume model based on the time of day and who was available in Dayton. However, the DFD Lt. offered that he could envision a scenario whereby he (personally) may receive a call and begin to run a model remotely from his home computer, if the situation dictated. DFD concluded that the Block 7 timeframe is reasonable because the data entries into NARAC are especially simple and do not require specialized computer skills.

The timeframe listed in Figure 2, Block 8 was also described as realistic by DFD, and the DFD captain and lieutenant both expected a plume prediction to come back even more quickly than theorized in Block 8. Both the captain and lieutenant agreed that Figure 2, Block 9 was a realistic timeline to make a decision regarding a SIP decision. Evacuation versus SIP regarding Block 9 was discussed and the DFD lieutenant saw value to being more precise with the SIP directive because in most cases evacuation is a tremendous challenge. The DFD lieutenant commented that CAMEO-ALOHA-MARPLOT was very useful in helping determine the long range effectiveness of SIP activity and referencing this software would be useful. The DFD lieutenant commented that NARAC plume predictions have special value by identification of specific plume concentrations which is complementary to the CAMEO-ALOHA-MARPLOT software. It is extremely challenging for DFD (most agencies) to evacuate persons in the highly contaminated areas of a plume, therefore, the best that might be accomplished is to give those exposed a definitive SIP direction as described in Figure 2, Block 9. Self-evacuation may not be feasible depending on population characteristics[25] of those requiring evacuation.

Regarding Figure 2, Block 11 the DFD lieutenant commented that it would be hard enough to deal with the affected population identified by the IMAAC plume prediction versus “notifying everyone” (an entire 10-mile radius for example) as a “failsafe” or “catchall” method to issue an alert. The NARAC map gives excellent guidance on how to focus SIP and/or evacuation activities most effectively. The DFD fire captain added that the precision inherent in NARAC is very important helping to

[25] Population characteristics includes characteristics such as ambulatory versus non-ambulatory; incarcerated versus non-incarcerated; children in locations absent their legal guardians (i.e., schools), etc.

more efficiently utilize limited resources. Also regarding Block 11, the DFD captain and lieutenant were optimistic that the prior-assigned dispatch personnel (before a DFD re-organization) could have been trained to log into IMAAC and access the model. DFD agreed that with proper training, current dispatch personnel would be able to be trained to log into IMAAC and view the plume prediction that was generated by DFD. With regards to Figure 2, Block 12 DFD agreed that if a jurisdiction had an adequate reverse 911 system that the plume prediction could be geo coded (draw the same geometrical shape around the plume) and a message sent to those affected by the plume. Actual SIP direction given to institutions may also be a smart practice. Further discussion summarized that timely SIP notification coupled with SIP pre-training for facilities, dependent upon professional staff, would be of considerable value in the interests of public safety. Facilities such as schools, hospitals, nursing homes, day cares, etc., may have no choice but to SIP because those types of facilities can be especially complicated to evacuate. While waiting the arrival of school buses or ambulances for example, it may be especially difficult to effect a total evacuation and a facility may have no other option but to SIP; therefore, it is especially important that people receive notification and direction based on accurate plume predictions and as quickly as possible in efforts to minimize event complications.

f. Toledo

Toledo Fire Department agreed that the times estimated in Blocks 3, 4, and 5 were readily achievable by a trained incident commander and/or a hazardous materials team. It would be somewhat dependent on an incident commander's (IC) ability to identify the source input needed to create the plume model. TFD noted the importance of source identification which would affect several varying aspects of an incident. TFD did not wholly commit; however, TFD did agree that the timelines listed Blocks 3, 4, and 5 are possible to attain using a trained IC who should be able to decide within the first 3-5 minutes whether or not to use plume modeling. Three minutes may be overly optimistic depending on the incident. But, TFD added that with proper training, three minutes is readily achievable for the decision points represented in Blocks

3, 4, and 5. TFD expressed concern that not enough people within their department had proper access to NARAC. Additional access, far beyond that which is presently available to TFD, is required. TFD added that seamless internet access is very important for any of parts this model to be effective.

TFD added that the Figure 2, Block 7 timeline (five minutes or less) was possible, but that this would be a significant challenge because of the multitude of potential distracters during this type of emergency scene. Five minutes is possible, but it is also possible that an IC could become overwhelmed with other issues causing a delay in the Block 7 estimated time. IC's would have to be trained very well to ensure that this (Block 7) took place in five minutes or less. This would be realistic for an IC, but not be realistic for a line officer. TFD emphasized that plume modeling is needed and that the fire service, overall, needs to become better-trained and educated regarding atmospheric air plume dispersion modeling. Because of the extended time lapses in between incidents requiring plume modeling, decision makers must remain up-to-speed in all aspects of these types of scenarios.

The Figure 2, Block 8 timeframe is realistic for TFD based on past experience, using NARAC in practice mode. The finished NARAC model comes back extremely fast during non-emergencies and the expectations that the models will come back at least as fast as practice mode are reasonable from the TFD perspective. The Figure2, Block 9 decision point is also reasonable based on the plume model result returned by an IMAAC web based model. Although TFD prefers assistance from other local agencies, TFD would be able to make a decision using IMAAC models to effect a SIP decision. Note: The author also prefers assistance from other agencies regarding this decision point whenever practical.

For TFD, the Figure 2, Block 11 decision point would be a challenge based on a jurisdictions' capacity to notify the public to SIP. If a jurisdiction had a system that geo coded and was able to alert those directly in the plume area, Block 11 is a realistic expectation. However, system operators must be very well-trained in the utilization of a reverse 911 type of system in order to skillfully interface a notification with an atmospheric air plume dispersion model to quickly notify those in the plume

path. Inaccurate notification or attempting to notify everyone with the same message regarding an emergency can cause more problems than it fixes. The capability to notify those in the path of the plume with an accurate and precise message has considerable value. TFD expressed concern about distributing the accurate plume information to those responsible for sending out a public protective action message. If TFD dispatch was trained on IMAAC system access, then it is realistic that dispatch could access a shared folder on the IMAAC website which contained exact plume prediction as created by TFD incident managers. Based on the respective plume prediction, TFD dispatch could be trained to send a message to the effected public.

According to TFD, Figure 2, Block 12 could become reality with a coordinated procedure detailing IMAAC system responsibility coupled with knowledge necessary for use of a reverse 911 or similar system. TFD adds that this must be very “tight” procedurally and those responsible must be trained properly. An EAS message or reverse 911 type of message could be distributed in a timely manner if such procedure and training existed. Plume modeling must become a priority when a situation dictates, and procedure must delineate responsibility for respective tasks. There must be procedures, training, and exercises that make plume modeling a front burner priority for the overall proposed framework model to work. If there is a lapse into long periods of plume modeling dormancy there is a chance (likelihood) that the aggressive timelines suggested in this thesis will remain unattainable.

Figure 3 is in many ways very similar to Figure 2. The most obvious distinction is that internet Web access may not always be available, and in such cases, OFM 3 represents a viable alternative to ensure public protective action directions (i.e., shelter in place) can still be disseminated with minimal delays.

3. IMAAC-Local Jurisdictions WMD Hazardous Materials Operations Framework Stand Alone Model Flowchart (Figure 3)

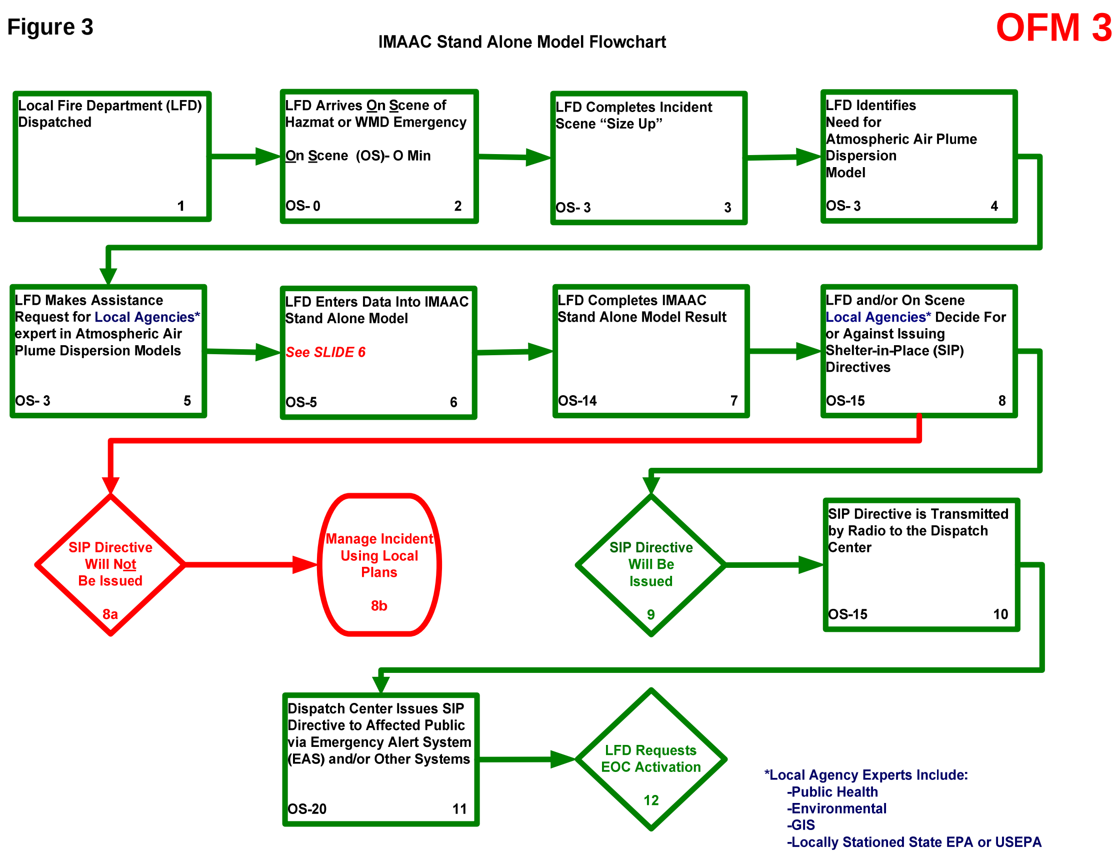

Figure 3. IMAAC-Local Jurisdictions WMD Hazardous Materials Operations Framework Stand Alone Model Flowchart

a. Akron

AFD agrees that a stand alone model is important if the internet is down, especially regarding this framework model. AFD presently uses CAMEO for this scenario. Figure 3, Blocks 6 and 7 would likely take more time depending on the plume model to be used. Data inputs into a non-Web-based model, including canned weather and GIS coordinates, would likely take longer making the timelines in Blocks 6 and 7 overly optimistic.

Regarding Figure 3, Block 10, AFD could fax or email a stand alone model plume prediction to the AFD dispatch that could then be used to draw a similar geometric shape (shape similar to plume dimensions) to notify people in the affected area to shelter in place. Although this would take longer, it could be accomplished. AFD would not depend upon dispatch to perform data entry into a stand alone model or into a Web-based model. A civilian run dispatch center would not be able to create plume predictions without hazmat technician level supervision, or guidance from an incident commander. However, the dispatch center would be capable of taking a stand alone plume model prediction, and apply the result to a similarly developed reverse 911 type of geometric shape, and then transmitting a SIP message to the effected population.

Note: Assumptions in the stand alone model scenario are similar to the Web-based model; however, the timeline for the stand alone model is likely overly ambitious.

b. Cincinnati

Cincinnati Fire Department commented that the IMAAC stand alone model option represented in Figure 3 is as important as an IMAAC Web-based plume model in cases when the internet was inaccessible during an emergency. A stand alone computer-based model (Figure 3) would be used in Cincinnati only as a backup since there would be no way to quickly incorporate real time weather into the plume prediction, which is a key component of NARAC.

c. Cleveland

Cleveland Fire Department could run the stand alone model remotely from an office and relay the information to a dispatch center responsible to provide an alert notification. The notification would be performed similarly to the Web-based model as long as the stand alone model plume prediction could be provided to dispatch in order to interface with a reverse 911 type of system as was discussed with the Web-based model. If CLE FD had no IMAAC access, it may be forced to default to another model or to the DOT ERG to create plume predictions that can be overly vague and generalized. A stand

alone model is needed, however, in case the Web is out of service. There are delays to using a stand alone model, but it can be accomplished. A stand alone model with topography incorporated into the model would be valuable according the CLE FD.

The time estimates in Figure 3, Blocks 6 and 7 are overly optimistic and may need to be revised. This would throw off much of the subsequent framework model time estimates. Figure 3, Block 10 would likely be delayed because transmitting a plume prediction by fax or email to dispatch would also take more time as compared to the Web-based model approach where the plume result is shared via a Web-based folder. CLE FD emphasized complications with stand alone plume models, but expressed that such plume model capability is still needed.

d. Columbus

Columbus Fire Department has some pre-run CAMEO plume models developed for local area critical infrastructure. Based on experiences in COL FD, a stand alone model will take longer as compared to a Web-based model such as IMAAC. The times listed in Figure 3, Blocks 6 and 7 will likely take longer. Because of this delay the other actions will be delayed accordingly as well. As far as the model usefulness, a stand alone model lacks real time weather data—a negative for COL FD. According to COL FD, the stand alone models in use at COL FD cannot be applied more quickly than the NARAC Web-based model or achieve precision similar to NARAC. Therefore, the times in Figure 3, with respect to Boxes 6, 7, 8, 9, 10, and 11, would likely require more time due to some of the delays inherent in stand alone models.

e. Dayton

The Dayton Fire Department agreed that a stand alone model assessment would be relatively similar as described in Blocks 3, 4, and 5. With regards to Block 6, data entries could be made relatively quickly as well into a stand alone model, but the results may come back much more slowly and not be nearly as accurate depending on the stand alone model selected. The result could be faxed or emailed to dispatch or the facility responsible to transmit the SIP directive as described in Block 10. DFD was

concerned that such stand alone models with which they were familiar lacked topography data and also lacked real-time weather data. DFD added that technology needed to more effectively utilize a stand alone model (Blocks 6 and 7), and to share the result efficiently (Block 10), might be lacking in many cities and would likely contribute to delays with the timeline as expressed in the thesis. There would likely be a delay in transmitting a shelter-in-place directive (Figure 3, Block 11) using a stand alone atmospheric air plume dispersion model

f. Toledo

Toledo Fire Department (TFD) analyzed that the stand alone model would take longer because of coordination delays inherent in coordination of a stand alone model with dispatch for use with a reverse 911 notification (Figure 3, Block 10), similarly as described with a Web-based model. TFD could produce a stand alone plume model, but absent real time weather (for example) and an increased data entry requirement, there would likely be significant delays relative to the overall estimated timeframe in the overall framework model (Figure 3). TFD added that at this point it may decide to visually look at a plume and make a decision to notify facilities by estimating the plume path. For example, TFD may notify major institutions that appear to be in the plume path based online of site or other visual observation.

TFD added that such a visual estimate and notification to affected facilities could take place before doing any plume modeling including a Web-based model. This type of approach could be more readily discussed in the context of smart practices or training programs. TFD agreed that this approach would not eliminate a need for plume modeling. This technique would be another option utilized to quickly notify potentially affected facilities of an atmospheric release resulting in a plume and to take appropriate protective actions. TFD concluded that a stand alone model is needed in case Web access is not available.

4. IMAAC-Local Jurisdiction WMD Hazardous Materials Operations Framework National Incident Management System and Unified Command Structure Model (Figure 4)

Figure 4 is representative of a proposed incident management structure several hours into an incident and takes into account the National Incident Management System from an incident perspective deemed useful for emergencies requiring atmospheric air plume disperse on modeling activities.

Figure 4 **OFM 4**

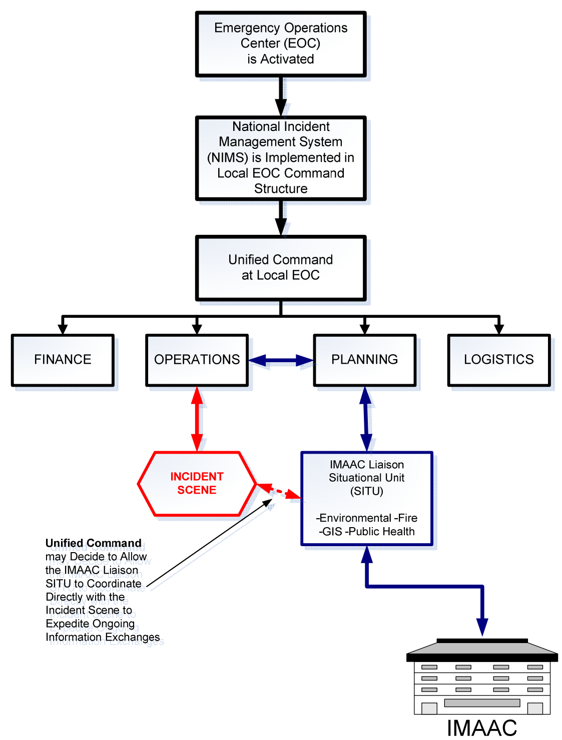

Figure 4. IMAAC-Local Jurisdiction WMD Hazardous Materials Operations Framework National Incident Management System and Unified Command Structure Model.

a. Akron

Akron Fire Department is versed with EOC operations, NIMS, and Unified Command, which are relatively commonplace for AFD and the city of Akron.

The Planning Section is the appropriate place for the IMAAC liaison as described in Figure 4. This allows for proper engagement of the other functionality taking place in the Planning Section for a respective incident. AFD is also alright with the IMAAC SITU coordinating directly with the incident scene versus having to go through Planning to Operations to the incident scene and inversely. The illustration in Figure 4 is reflective of traditional fire service incident command structure and is reflective of how AFD would presumably coordinate an incident requiring atmospheric air plume dispersion modeling.

b. Cincinnati

The Cincinnati Fire Department representative concluded that long-term incident coordination between the local jurisdiction and IMAAC was properly represented by placing the IMAAC Situational Unit in the Planning Section and within the National Incident Management System construct. CIN FD also added that it would be preferable to have the local SITU in direct contact with the on scene incident command and IMAAC, as long as the local SITU kept the Planning Section fully informed. Planning in turn would ensure that the Operations Section and Unified Command remained fully-informed throughout the incident.

c. Cleveland

The Cleveland Fire Department representative concluded that the local IMAAC Situational Unit belongs in the Planning Section within NIMS (Figure 4). Planning is especially important for atmospheric air plume dispersion model incidents of long duration due to the importance of identifying exposures, which could drive future actions as related to the incident. For example, accurate plume modeling in the short-term and in the long-term will have varying usefulness in efforts to distinguish areas affected from those not affected. CLE FD felt that the information should flow through the SITU to the Planning Section to Operations to the Incident Scene and in reverse. CLE FD did not think it was a good idea to place the SITU in direct contact with the incident scene, even if they kept the Planning and Operations Sections informed. CLE

FD contended that it was important to remain consistent with NIMS and not to deviate from NIMS by allowing the SITU to directly communicate to the incident scene.

d. Columbus

The Columbus Fire Department representative is alright with the IMAAC SITU keeping the incident scene directly informed as long as the Operations and Planning Sections remain informed of the information (Figure 4). The direct connection to the incident scene may minimize misunderstandings or data confusion by allowing the local SITU to communicate directly to the incident scene, and to IMAAC, especially since over the long-term, ongoing plume modeling functionality can require complicated data inputs and other analysis. According to COL FD, too much could get lost in translation if the SITU was forced to follow a circuitous NIMS pathway. It is important, however, to keep the Section Chiefs informed and Unified Command fully-apprised. For COL FD, it is not important that complicated scientific exchanges go through the respective Section Chiefs.

e. Dayton

Dayton Fire Department (captain) advised that NIMS would be used for long-term incident management. DFD was alright with the IMAAC SITU eventually assigned to the Planning Section; however, a local department may initially assign such plume modeling expertise as technical advisors directly to the Operations Section. After an incident progressed for several hours, DFD saw the value to placing the local IMAAC SITU into the Planning Section. The DFD Lieutenant identified the direct link between the local jurisdiction IMAAC SITU and the incident scene as **Fayols Bridge** and added that this was considered a smart practice in some fire incident management literature. Therefore, DFD concurred that the local SITU belonged in the Planning Section and that it is alright for the local SITU to have a direct link to the incident scene (such as Fayols Bridge).

f. Toledo

The Toledo Fire Department uses NIMS for incident management organization and operations. TFD sees the local SITU residing in the Planning Section and closely tied to the Operations Section for different operational phases involving atmospheric air plume dispersion modeling. The Planning and Operations Sections must remain “tight” during this ongoing incident scene management. It is important that field units remain in contact with the local SITU and that the local SITU remain in close contact with IMAAC. Direct interaction with minimal interference during such complex incidents is preferred by TFD to ensure a seamless exchange of scientific and operations information and for ongoing incident management and coordination.

5. IMAAC-Local Jurisdiction WMD Hazardous Materials Operations Framework Support Model (Figure 5)

Figure 5 is a step back from on-scene incident management and is representative of the building blocks necessary for many of the proposed objectives represented in Figures 1, 2, 3, and 4. Procedures, training, exercises, and funding perspectives are foundational to the structure, coordination, and execution as represented in OFM 1, OFM 2, OFM 3, and OFM 4 as elements of the IMAAC-Local Jurisdiction Operations Framework Model.

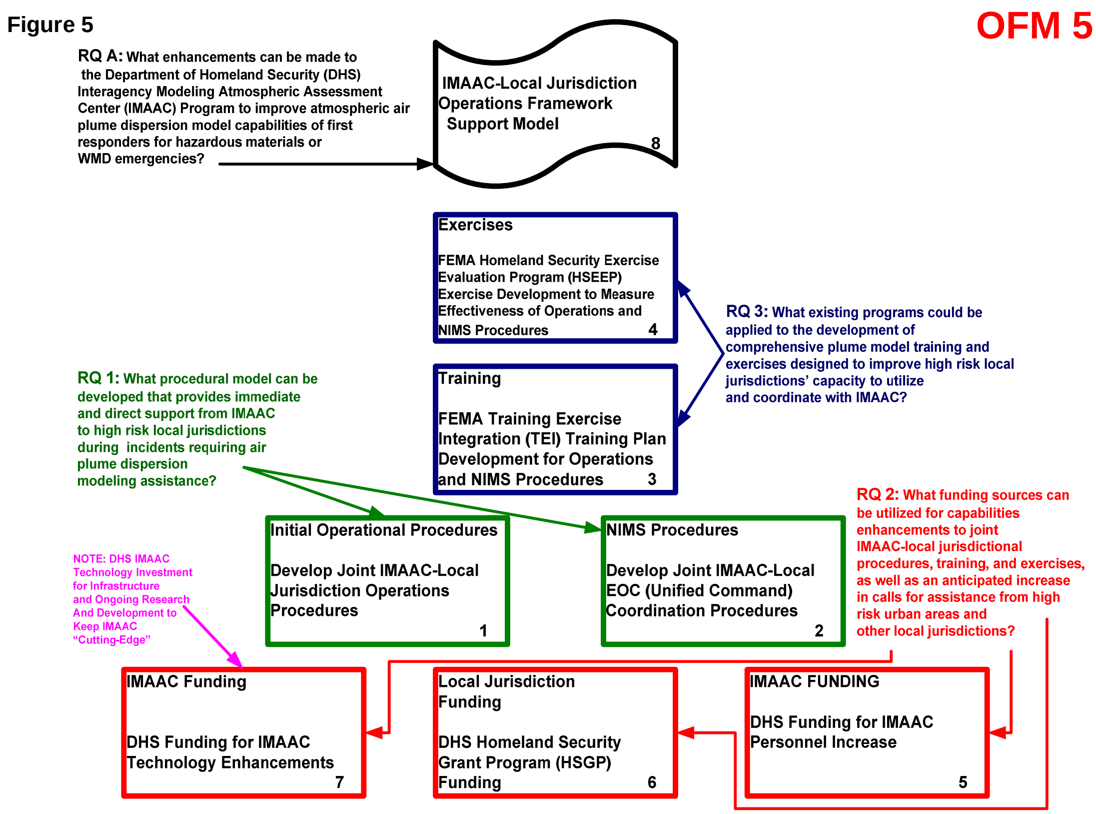

Figure 5. IMAAC-Local Jurisdiction WMD Hazardous Materials Operations Framework Support Model

a. Akron

The Akron Fire Department representative commented that Figure 5, Boxes 1 and 2 are necessary for local jurisdiction coordination with IMAAC. Procedures are presently lacking with regards to incident coordination, the development of which would assist with several aspects detailed in Figures 1, 2, 3, and 4.

AFD was especially interested in drills, training, and exercises as noted in Figure 5, Blocks 3 and 4. It is not a smart practice to expect well-coordinated procedures absent training and exercises. Training will help operators attain skills needed to utilize the IMAAC system and is very important for chief officers and Summit County (Akron) hazmat teams. Key players need to be educated and trained with IMAAC to ensure seamless incident coordination. After an incident has begun is the wrong time to try to

develop a coordinated procedure if IMAAC is to have optimal value. Figure 2, Block 6 was considered to be realistic to be used as a funding source to help formulate procedures, training, and exercises and to execute the same. AFD offered that involvement with the Summit County Local Emergency Planning Committee (LEPC) would be a good starting point to integrate IMAAC procedure development and to ensure standardized procedures (Figure 5, Blocks 1 and 2) are properly addressed through training and exercises. AFD is aware of the need revisit NARAC in the context of plume modeling capability.

AFD reiterated the benefit of a coordinated IMAAC approach and IMAAC integration into AFD operations (Figure 5, Blocks 1 and 2). IMAAC procedures are needed in order to facilitate use at the local level. AFD emphasized the importance of notifying an effected population with an accurate plume model, versus the "entire city" for example, which could also be addressed through training and exercise programs (Figure 5, Blocks 3 and 4). AFD emphasized the benefits of disrupting a minimal number of people and institutions during an emergency. For example, if the entire city was notified of a chemical emergency that only affected a smaller section of town, parents could dangerously descend upon schools throughout the city if they have not received some assurance that their child's school was not at all involved in the incident. In this example, parents would be advised not to go to a child's school, especially if the school was in the path of the plume. However, parents must have the confidence that schools understand how to properly shelter in place during hazardous materials or WMD emergencies. Similarly, it would not be prudent to immediately notify all hospitals, nursing homes, and/or day cares of a hazardous materials incident, especially if those same institutions were not directly affected by the plume prediction. AFD emphasized that the accuracy of a plume prediction like IMAAC would help responders do a better job alerting those specifically in harms' way versus notifying the entire 330 area code (Akron, Ohio) in this example.

b. Cincinnati

The Cincinnati Fire Department representative expressed concern that local operational procedures (Figure 5, Blocks 1 and 2) coordinating with IMAAC are extremely important but lacking; such procedures must be developed if Figures 1, 2, 3, and 4 are going to be realized. On-scene and Emergency Operations Center incident coordination were presently very "loose" in Cincinnati and largely dependent on "who" was in town (locally) at the time of an emergency for IMAAC to be optimally useful. This amplifies a need for coordinated local jurisdiction-IMAAC procedures as noted in Figure 5, Blocks 1 and 2. CIN FD agreed that training must be developed and regularly practiced if local fire departments are to become "expertly" capable of creating and applying IMAAC plume models in the earliest incident stages.

The CIN FD rep was unfamiliar with FEMA Training Exercise and Integration (Block 3) and the Homeland Security Exercise Evaluation Program (Block 4), but emphasized the importance of (especially) training, and less-so, exercises as a measure of training effectiveness. In summary, exercises are important, but not as much as the training. Finally, the CIN FD representative had some familiarity with the DHS Homeland Security Grant Program (HSGP) and was fairly certain that funds would be approved for development of procedures, training, and exercises, necessary for Figures 1, 2, 3, and 4 to be realized for CIN FD.

c. Cleveland

The Cleveland Fire Department representative emphasized the importance of several aspects of Figure 5, including Boxes 1 and 2. Joint operational procedures are needed between IMAAC and local jurisdictions. Operations will be less effective if there is not a uniform operations/coordination procedure. It is also important that other disciplines be incorporated into such a procedure in addition to the local fire department. GIS, environmental, public health and other subject matter experts in addition to fire could provide better direction and make better long-term decisions in the context of an incident if there was an integrated/coordinated IMAAC procedure.

Figure 5, Box 3, for CLE FD emphasized that whatever training was developed for plume modeling, that the National Fire Protection Association (NFPA) be taken into account. CLE FD noted that it is very important to take NFPA into consideration when developing a fire service training program. The National Incident Management System is also very important for whatever training is developed with NIMS education incorporated into the course. CLE FD concurred with the concept explained in Figure 5, Box 3 because of the importance and value of course institutionalization which can be achieved through the Federal Emergency Management Agency Training Exercise Integration Program. Course institutionalization allows for use of homeland security grant funds to develop, administer, and attend training such as an institutionalized atmospheric air plume dispersion modeling training course. FEMA TEI has been used for training by CLE FD and has been useful for logistical and funding reasons. Training is an ongoing issue and is foundational to successful utilization of IMAAC and related complex plume model concepts.

The Figure 5, Box 4 FEMA Homeland Security Exercise Evaluation Program (HSEEP) is also important and would contribute to development of knowledge and expertise for IMAAC system users. HSEEP could help identify weaknesses which can be corrected with a standardized process for exercise implementation. Overall, it is important to have a standardized exercise programmatic approach so the nation is training and exercising consistently. CLE FD is approaching from a perspective that NARAC is a very useful atmospheric air plume dispersion model tool and interdisciplinary training is a key if responders are going to use the tool as skillfully as possible. It is important to produce fast and accurate plume predictions during emergencies, and it is equally important that responders are capable of skillful understanding, interpretation, and application of plume model predictions. It is also important to understand the effectiveness of shelter in place for specific incidents by using IMAAC in concert with CAMEO-ALOHA-MARPLOT shelter-in-place effectiveness estimation software.

d. Columbus

The Columbus Fire Department emphasized the importance of Figure 5, Blocks 1 and 2. The procedure development between IMAAC and local jurisdictions is crucial for coordination especially for incidents of long duration. COL FD uses HSEEP (Figure 5, Block 4) and sees value to using HSEEP for IMAAC exercises. COL FD also sees support from the local committees charged with HSGP funding responsibility, especially if grant funds committee members understood the differences between IMAAC and other plume model programs currently in use. COL FD was of the opinion that there would be support locally from the local inter-disciplinary sub committees for development of procedures (Figure 5, Blocks 1 and 2), training (Figure 5, Block 3), and exercises (Figure 5, Block 4). COL FD also sees value to developing a standard training program that would be universally applicable to jurisdictions using IMAAC (Figure 5, Block 3).

e. Dayton

The Dayton Fire Department representatives expressed concern regarding the absence of coordinated procedures and both (captain and lieutenant) were very supportive of the development of IMAAC local jurisdiction procedures (Figure 5, Blocks 1 and 2). Both concurred that procedures are needed and that it is still unclear if NIMS (Block 2) had substantively taken hold throughout the nation. DFD was concerned that NIMS was not fully integrated nationally.

DFD emphasized that course institutionalization (Figure 5, Block 3) is very important as DFD has recently had access to a FEMA TEI course. DFD agreed that capitalization on the FEMA TEI program was the correct training approach through which to develop an IMAAC training course universally applicable to local jurisdictions. The fact that FEMA TEI allows for use of HSGP funding to deliver and attend training makes TEI a smart choice, according to DFD representatives. DFD summarized the importance of using FEMA TEI as a way to standardize an IMAAC training course in support of ongoing and consistent delivery of an atmospheric air plume dispersion modeling program. DFD also emphasized the importance of utilizing the FEMA HSEEP

(Figure 5, Block 4) to help ensure that training and exercises are consistently executed. HSEEP is a very good means by which to measure the effectiveness of training.

Finally, DFD agreed that the local HSGP funding (Figure 5, Block 6) committee would be supportive of IMAAC procedure development, training, and exercises. The DFD captain expressed that IMAAC is very important and a framework model such as the one proposed would help solidify the nations' capacity to perform atmospheric air plume dispersion models during hazardous materials or WMD emergencies. DFD emphasized the importance of plume modeling capacity in the context of many of the DHS National Planning Scenarios affirming a need for implementation of OFM elements foundational to Figure 5, Blocks 1, 2, 3, 4 and 6. DFD summarized that Figure 5, Blocks 5 and 8 are equally as important regarding enhancements to IMAAC infrastructure, research and development, but DFD was not comfortable commenting further without additional information.

f. Toledo

The Toledo Fire Department representative offered that Figure 5, Blocks 1 and 2, are extremely important. Procedures at the incident command level and at the dispatch level with respect to notification coordination are extremely important. Procedures are lacking and need development to assist with complex incident scene coordination which can be achieved through development of IMAAC-local jurisdiction procedures. DFD added that similar procedures are needed nationally for better coordination short- and long-term. TFD stated that procedures are critical for local jurisdictions and would appear to be critical for IMAAC, which could potentially be tasked to coordinate with dozens of different cities nationwide. Procedures development would also appear to be of particular value from an IMAAC perspective.

TFD concluded that Figure 5, Blocks 3 and 4, are also very important for implementation of ideas as developed in Figures 1, 2, 3, and 4. Incidents requiring plume modeling are complex and require equally sophisticated training and exercises. Plume model incidents may not recur frequently enough to justify spending significant amounts

of funding; however, these types of incidents are serious enough, both in theory and reality, that the nation does not have the luxury of the status quo, much less a substandard response.

TFD was optimistic that the local Toledo urban area would be supportive of using HSGP funds (Figure 5, Block 6) to enhance procedures, training, and exercises focused on atmospheric air plume dispersion modeling. TFD offered that the local LEPC and local state homeland security grant fund group would also be supportive of using funding for IMAAC developments for hazardous materials and WMD CBRNE planning and response. TFD is dutifully focused on prevention but realizes that prevention is not full proof. TFD expressed the importance of remaining current with air plume modeling and keeping the IMAAC capability cutting edge to keep pace with emerging global threats. There is a danger that tools such as IMAAC can get shelved if training does not become institutionalized and user-friendly.

TFD expressed concern regarding the federal coordination requirement for IMAAC assistance that could potentially delay IMAAC use by local jurisdictions until several hours into an incident. Immediate and skillful access along with proper training and exercises are critical to saving lives. Systems such as IMAAC need to be pushed down to the lowest jurisdictional levels to be consistent with HSPD 8, especially for serious or catastrophic incidents. Development of regional and/or statewide procedures for IMAAC would be extremely beneficial. TFD warned against potential short-sightedness inherent in waiting for another major terrorist incident before getting IMAAC "squared away" nationally. Using IMAAC for shelter-in-place directives in the earliest incident stages will have a significant positive impact on public safety for related types of emergencies.

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VI. FINDINGS AND RECOMMENDATIONS

This final chapter is focused on discussion and revision of the Local Jurisdiction-Interagency Modeling Atmospheric Assessment Center Hazardous Materials/Weapons of Mass Destruction Operations Framework Model. Revisions, findings, and recommendations based on literature and interview data acquired throughout this thesis process are synthesized within this chapter.

During interviews, several ideas and adjustments were discussed altering some elements of the originally-proposed Operations Framework Model as described in Chapter III. Not all interviewee constructive criticisms were integrated into the model revisions. Each OFM figure was evaluated separately and based on interviewees' prior experiences and knowledge of hazardous materials incidents and the National Atmospheric Release Advisory Center during incidents, training, and exercises. The revisions to models in Chapter VI are followed by recommendations both designed to improve model shortcomings that were mutually agreed upon by the interviewer and interviewees and add to overall OFM effectiveness.

Findings, including proposed OFM actions and benchmarks elemental to OFM 1, OFM 2, OFM 3, OFM 4, and OFM 5, have been generally validated by interviewees with consideration to revisions/changes to be discussed throughout this chapter. Finally, related findings and recommendations are based on the perspective of local first responders, the public safety mission of which was the core of this thesis project.

Figure 6 is a revision of Figure 1, OFM 1 (Chapter 3 Model) with findings from the interviews integrated into the newly revised figure.

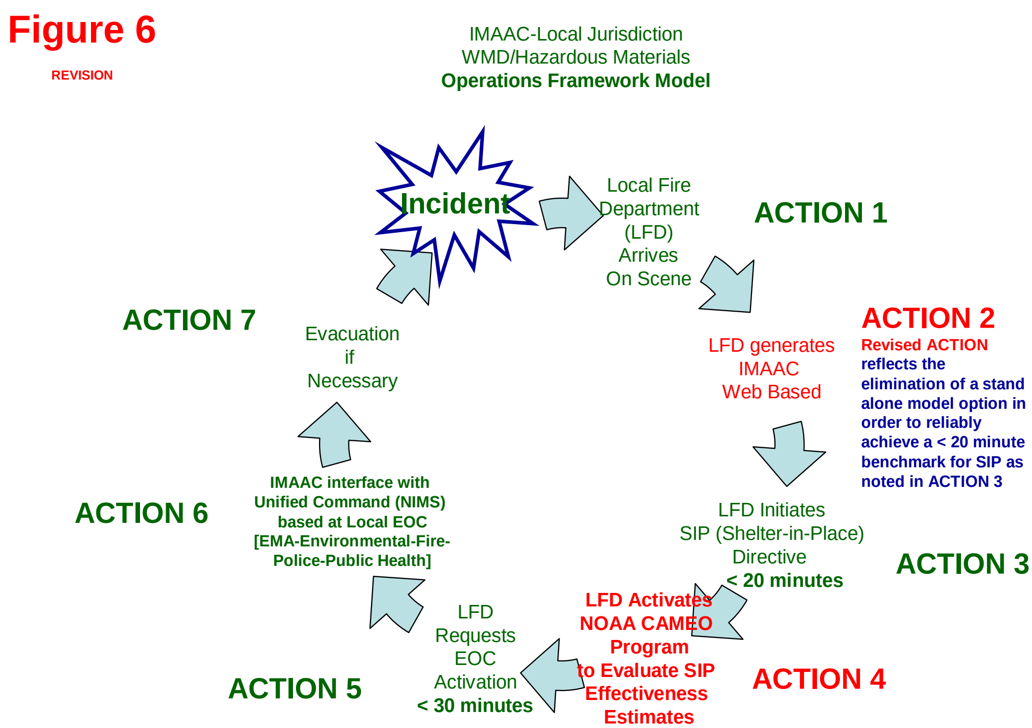

Figure 6. Operations Framework Model Revision 1

Figure 6, Action 2 was revised based on interview feedback challenging original overly optimistic time projections associated with stand-alone plume model programs as compared to the IMAAC Web-based atmospheric air plume dispersion modeling program.

A. FIGURE 1 OFM 1 FINDINGS

The primary criticism of original Figure 1 (Chapter III) took place with regard to Action 2. All six fire department representatives concluded, either during the initial phase or later interview phases that an IMAAC or other type of stand alone model would likely take significantly longer to acquire a plume prediction as compared to the IMAAC

Web-based atmospheric air plume dispersion model. This is testimony to the effectiveness of the IMAAC Web-based model.

However, the initial assumption by the researcher that an IMAAC stand alone model could be used to generate a plume prediction as quickly as the IMAAC Web-based model was overly optimistic. Therefore, the stand alone model option was totally removed from Figure 1, Action 2 (see Figure 6, Action 2). Adjusting Action 2 by removing the stand alone model option from this step allows for the remaining Actions (Figure 6, Actions 4, 5, 6, and 7) to remain in tact. Departments agreed that some kind of stand alone plume model option was necessary, but that time associated with such a model would likely be slower as compared to the IMAAC Web-based model. Figure 8, OFM 3 (below), which focuses solely on the stand alone plume model option, was significantly restructured based on the interview data. Note: The addition of (Revised Action 4, see Figure 6) represents the operation of the CAMEO system in concert with a decision to issue SIP directives. The CAMEO software will provide a local fire department and partner agencies a means to begin formulating SIP effectiveness predictions discussed more in the following sections.

Two departments expressed concern that Action 7 (Evacuation if Necessary) may make more sense earlier in an incident life cycle. By utilizing software such as CAMEO-ALOHA-MARPLOT, time estimates of shelter-in-place effectiveness could be estimated dependent upon variables such as building construction as well as the type and concentration of chemical released. This is reflected in the OFM revision as (new) Action 4 (see Figure 6). The researcher agreed with the suggestion to consider earlier evacuation to a certain extent. It may make sense for some segments of the population to begin evacuation immediately, depending upon their location with respect to estimated plume concentrations. Such concentration estimates could be derived with some degree of accuracy by using IMAAC plume predictions.

Nevertheless, these same departments conceded that certain facilities such as hospitals, nursing homes, schools, day cares, prisons, orphanages, and other such facility types would initially have little choice but to adopt a shelter-in-place strategy versus immediately beginning with an evacuation. Delays, such as waiting for ambulances or

school buses to begin evacuation, would take time to organize; there will likely be inadequate numbers of specialty vehicles available (quickly) during such an emergency. Furthermore, in addition to evacuation resource delays, vehicles and accompanying personnel may not be properly equipped to enter a contaminated area to effect evacuation in a safe and timely manner. It is a combination of these types of variables which arguably makes sheltering in place an optimal strategy option for high occupancy and/or convalescent-types of facilities located in the path of a plume. Quickly disseminating pointed messages such as shelter-in-place directives to high life hazard facilities and to the general public may become the single most important action taken by emergency responders during hazardous materials or weapons of mass destruction emergencies.

Finally, some overall concerns focused on what could be considered as an aggressive timeline to issue shelter-in-place protective action directives dependent upon incident commander or hazardous materials team ability to quickly identify the source term of a chemical spill, release, or discharge. This is a valid concern and could significantly delay accurate plume model projections; however, accurate source term identification would cause significant delays regardless of what plume model program is used. Source term default strategies for incident "unknowns" accompanied by requisite training programs need be addressed through support of IMAAC programmatic enhancements, including support personnel increases accompanied by ongoing research and development as addressed by Figure10.

B. FIGURE 1 OFM 1 RECOMMENDATIONS

1. Maintain the objective reflected in Figure 1, Action 3 which is as follows: In 20 minutes or less, a local fire department can issue a shelter-in-place directive to a threatened population with assistance from a departments' respective dispatch center.

2. As depicted in the Figure 1 revisions (Figure 6), eliminate the IMAAC stand alone model provision from Figure 1, Action 2 and shift the emphasis to the IMAAC Web-based model option as a means to quickly develop atmospheric air plume modeling predictions used to drive shelter-in-place and evacuation public protective actions.

3. Develop an algorithm addressing situations when the source term of an incident release is not readily identifiable to allow a local fire department to minimize delays with subsequent IMAAC Web-based plume model predictions

4. Supplemental to Figure 1, Action 3 (new Action 4, Figure 6) instruct local fire departments operating within this paradigm to concurrently operate software complementary to IMAAC that provides time estimates of shelter-in-place effectiveness respective to a particular incident. This is represented by the addition of Figure 6, new Action 4 reference CAMEO.

Figure 7 is a revision of Figure 2, OFM 2 (Chapter III Model) with findings from the interviews integrated into the newly revised figure.

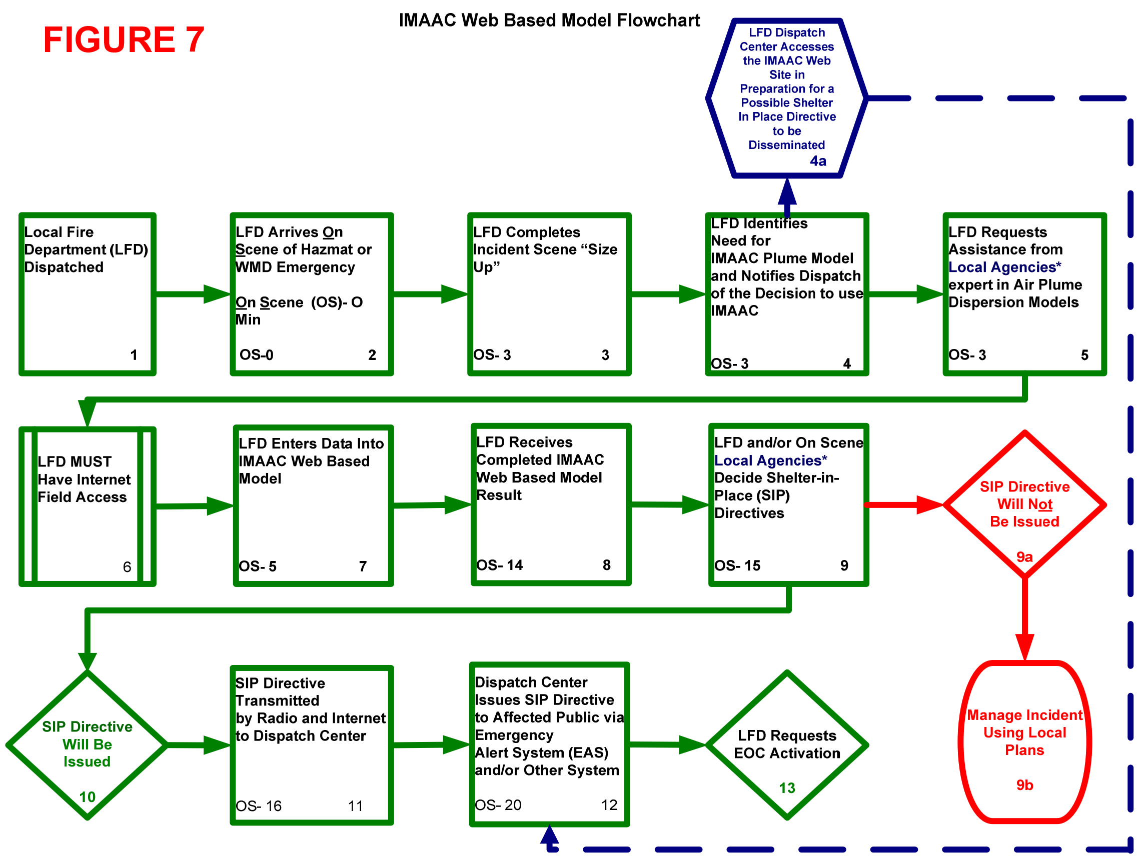

Figure 7. Operations Framework Model Revision 2

Figure 2 (OFM 2) (revised as Figure 7) was designed to isolate benchmarks beginning with incident on-scene arrival up to and including transmitting a shelter-in-

place order to an affected population. This framework model focuses exclusively on utilization of the IMAAC Web-based model and subsequent decisions based on the model prediction potentially used to effect public protective action such as sheltering in place.

C. FIGURE 2 OFM 2 FINDINGS

All departments concluded that actions related to scene size up, mutual aid requests, and a decision to use atmospheric air plume dispersion modeling during an incident were readily-achievable in three minutes or less as represented in Blocks 3, 4, and 5 in Figure 2, OFM 2. However, based on interview analysis, one notable change has been made in these early stages of Figure 2, OFM 2. Because of concerns expressed related to a dispatch center’s capability to access the IMAAC web and transmit a shelter-in-place directive in a relatively compressed time frame as previously designated by the on scene minus 16 minutes benchmark, a new benchmark or “block” has been inserted into Figure 7 as a revision to Figure 2, OFM 2 framework. Block 4a (Figure 7) represents a local emergency alerting agency (i.e., dispatch center for all cities in this study) performing a pre-planned action to concurrently access IMAAC in early incident stages (on scene minus three minutes) in concert with the local fire department decision point (Block 4) to effect a plume model, which will eventually be needed for ongoing incident management (Figure 7). This alleviates some pressure on a dispatch center by allowing for an additional 13 minutes to prepare to geo code the plume prediction using a reverse 911 type of system as described in Chapter V, and to quickly disseminate a shelter-in-place directive as advised by the on scene incident commander or hazardous materials unit.

Because of interviewee experience using IMAAC, there was unanimous confidence that a plume prediction result could be attained in 14 minutes or less as described by Figure 7, Block 8 (time unchanged from the original Figure 2, OFM 2, Block 8). All interviewees agreed that this is the type of system that needs to be supported and expanded in order for fire department personnel to disseminate definitive and timely direction to the public in the critical early stages of a weapons of mass

destruction or hazardous materials emergency incident. Interviewees were unanimous that in order for the aggressive OFM 2 timeline[26] to become a reality that many of the proposed model elements as listed in Figure 5, OFM 5[27] would require implementation.

It was also a generalized conclusion from a local jurisdiction perspective that the original Figure 2, OFM 2 timeline is desirable and that on scene incident commanders and hazardous materials teams could be educated and trained making the timeline in Figure 2, OFM 2 a realizable goal. Interviewees preferred to have support from local subject matter experts (Figure 7, Block 9), such as environmental or public health agencies, but concluded that a fire department incident commander or hazardous materials team could attain a knowledge, skills, abilities level to where he or she could make an appropriate shelter-in-place decision if circumstances dictated and mutual aid interdisciplinary support was not immediately available to assist with a shelter-in-place decision. Interviewees repeatedly emphasized that such an aggressive model would require development of joint local jurisdiction-IMAAC procedures (Figure 5, Blocks 1 and 2) reinforced by coordinated and regularly-scheduled training and exercises (Figure 5, Blocks 3 and 4) for those potentially involved in these types of scenarios.

Finally, with respect to Figure 2, OFM 2 and shelter-in-place directives issued to the public (Figure 2, OFM 2, Block 12), sheltering in place is only as effective as a populations' ability to take appropriate actions when so-advised. If the public is uniformed, ignores direction, or is SIP-challenged, then the directives advising shelter in place will have limited if any value. While individuals' reactions during emergencies can be unpredictable, it may be a smart practice for a local agency to focus SIP training and education efforts on institutions such as hospitals, nursing homes, and schools. As discussed earlier, since evacuation could arguably be extremely challenging for these types of institutions, such facilities' may be more receptive to pre-planned strategies designed around shelter in place in the context of hazardous materials or weapons of mass destruction incidents. If that is the case, populations at these types of facilities will

[26] SIP directive in 20 minutes or less.

[27] Development of Procedures (Figure 10, Blocks 1 and 2), Training (Figure 10, Block 3), and Exercises (Figure 10, Block 4).

be critically dependent on timely and accurate notification of a hazardous materials plume headed in their direction. Properly performed SIP activities will take time dependent upon the type of building to be protected and how well the staff is organized with respect to SIP activities.[28] Informing facilities of the capabilities created by Figure 7 prior to an incident would likely instill confidence reassuring convalescent and institutionally-dependent populations that such disasters can have successful outcomes.

D. FIGURE 2 OFM 2 RECOMMENDATIONS

1. Alter Figure 2, OFM 2, Block 4 to include Block 4a (depicted in Figure 7) to notify a department's alerting agency (i.e., dispatch center) to prepare for a possible public shelter in place alert by pre-planning earlier IMAAC Web access by the dispatch center when so advised by the on scene incident commander or hazardous materials team.

2. Provide access to IMAAC for an adequate number of DHS Urban Area Security Initiative and Metropolitan Medical Response fire departments enabling high risk local jurisdictions to have adequate, immediate, and unrestricted access to the IMAAC Web-based model tools critical to Figure 7 viability.

3. Require the DHS UASI and MMRS high risk urban areas granted adequate system access (Recommendation 2) to provide a detailed written strategy to DHS reflective of that jurisdiction's 18 month plan to effectively provide shelter-in-place training and education to all schools, hospitals, nursing homes, orphanages, prisons, daycares and other similar types of facilities within their respective core city and core county urban area.[29]

[28] SIP could include actions such as moving populations on lower floors to upper floors, shutting off air handling equipment, sealing off building openings, etc. SIP requires a coordinated and well-rehearsed plan commensurate with respective building and population complications.

[29] In 2002–2003, the DHS UASI grants program designated a core city and core county for respective high risk urban areas. The core city and core county are fiscally and programmatically responsible for administration of the UASI grant program (DHS, 2003). DHS UASI areas could be mandated to participate as a condition of a UASI grant award. A similar parallel could be used for the 124 MMRS cities nationwide. Since the DHS MMRS program arguably lacks focus at the national level (researcher's claim based on eight years as MMRS program coordinator for Cincinnati and most recent attendance at MMRS National Conference in Charlotte, North Carolina, June 11th, 2009)), this could become an MMRS strategic priority for subsequent grant years. MMRS cities electing to adopt this strategic priority would be granted adequate IMAAC system access similarly to DHS UASI areas (Recommendation 2). In addition to the previously cited reference and conference, this information is also based on the experience/role of the researcher as the City of Cincinnati Metropolitan Medical Response System Coordinator (2002-presnet) and Core City Point of Contact for the DHS Urban Area Security Initiative Program from 2003 to present.

Figure 8 is a revision of Figure 3, OFM 3 (Chapter III Model) with findings from the interviews integrated into the newly revised figure.

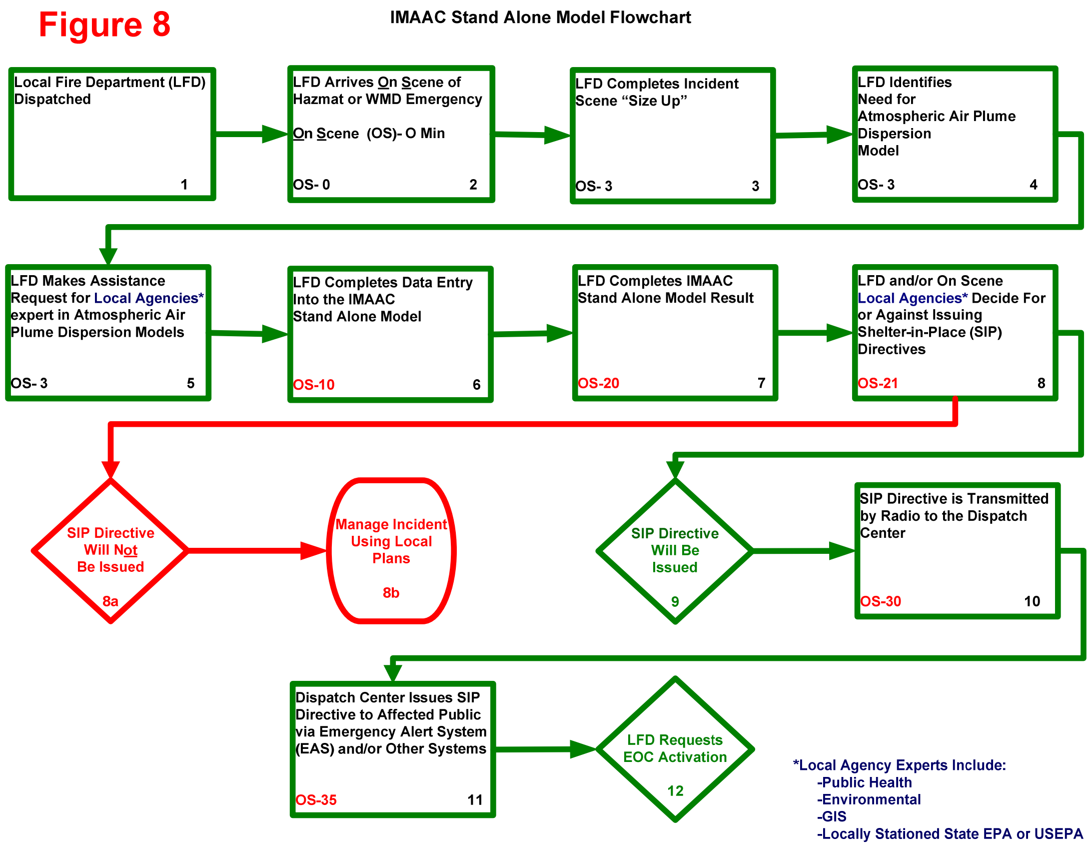

Figure 8. Operations Framework Model Revision 3

Figure 8 is in many ways very similar to Figure 7. The primary distinction focuses on the possibility that internet Web access may not always be available, and in such cases, Figure 8 is intended to provide a means by which to achieve incident outcomes similar to that as represented by Figure 7.

E. FIGURE 3 OFM 3 FINDINGS

The universally agreed upon conclusion (among interviewees) was that the estimated times beginning with Figure 3, OFM 3, Block 6 and Block 7 were overly optimistic. Interviewees have had limited exposure to an IMAAC stand alone model and

were basing their much of their analyses on experience with stand alone plume model systems presently in use at their respective departments. Very generally speaking and with inconsequential IMAAC stand alone plume model experience, interviewees recommended that times associated with Figure 3, OFM 3, Blocks 6, 7, and 8 be increased anywhere from 10 to 15 minutes depending on the level of training and experience with stand alone atmospheric air plume dispersion models. These associated time increases are reflected in Figure 8. Based on interviewee feedback, and researcher familiarity with some of the inherent complexities using stand alone plume model software, the researcher concluded that time increases are in order for Figure 3, OFM 3, Blocks 6 and 7 with respect to stand alone plume model data entry and results retrieval. These time increases are reflected in Figure 8. Figure 3, OFM 3, Block 8 could still occur one minute or less after obtaining a plume model prediction as depicted in Figure 8, Block 8.

Interviewees further concluded that there would be complications inherent in Figure 3, OFM 3, Block 10 associated with efficiently transmitting a plume prediction representation by fax, e-mail or some other means dependent upon methods available to respective jurisdictions. These complications did not exist with Figure 2, OFM 2, Block 11; they were avoided by having the alerting agency (i.e., dispatch center) log into the IMAAC website and extracting the exact plume prediction created at the incident scene. Complications associated with Figure 3, OFM 3, Block 10 could be overcome, however, based on researcher's experience and interviewees' analyses there remain historical challenges with sharing information such as plume predictions beyond the computer on which the prediction is formulated absent web, mesh network, or other wireless forms of communication. Therefore, Figure 3, OFM 3, Block 10 has been revised in Figure 8 to reflect time delays associated with the transfer of a stand alone plume model prediction from the computer on which it was generated to an alerting agency (i.e., dispatch center). Additionally, the same delay with this process would cumulatively affect Figure 3, OFM 3, Block 11. There should, however, be minimal delay in disseminating a reverse 911

shelter-in-place directive once a plume model prediction has been received by the alerting agency (i.e., dispatch center). The Figure 3, OFM 3 time adjustments are reflected by revisions in Figure 8.

F. FIGURE 3 OFM 3 RECOMMENDATIONS

1. Development and adequate dissemination of an IMAAC stand alone atmospheric air plume dispersion model program is designed to be as user-friendly and as accurate as possible as compared to the IMAAC Web-based model

2. As related to Figure 2 (revised as Figure 7), OFM 2, Recommendation 2, coordinate with the DHS Grants Program Directorate to engage DHS UASI and MMRS awardees through (already) required urban area strategy documents to identify and demonstrate a capability by which to seamlessly transfer IMAAC stand alone plume model results from a field unit to a local alerting agency (i.e., dispatch center) to provide basis for a reverse 911 or similar media type of shelter-in-place alert message

3. As related to Figure 2 (revised as Figure 7), OFM 2, Recommendation 3, coordinate with the DHS Grants Program Directorate to engage DHS UASI and MMRS grant awardees through (already) required urban area strategy documents to address atmospheric air plume dispersion model capabilities and to specifically identify a means by which to disseminate shelter in place information using a reverse 911 or similar type of system.

Figure 9 is a revision of Figure 4, OFM 4 (Chapter III Model) with findings from the interviews integrated into the newly revised figure.

Figure 9

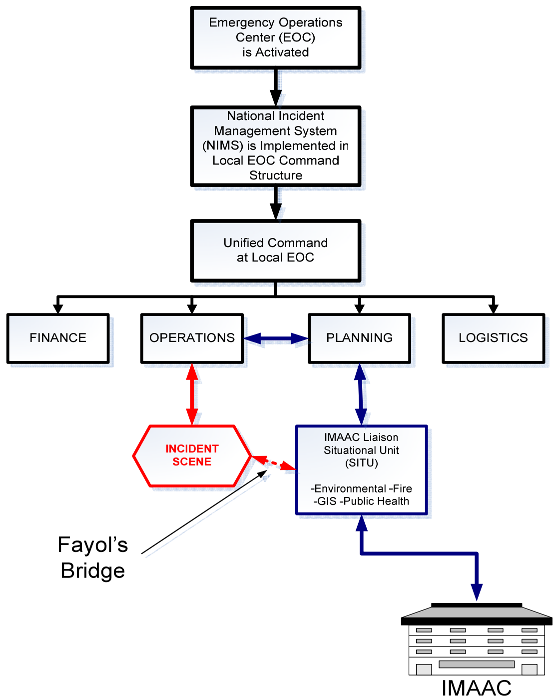

Figure 9. Operations Framework Model Revision 4

Figure 4 (OFM 4) (revised as Figure 9) is representative of a proposed structure several hours into an incident life cycle and integrates the National Incident Management System from a perspective involving atmospheric air plume dispersion modeling.

G. FIGURE 4 OFM 4 FINDINGS

Figure 4, OFM 4 resulted in the least amount of feedback with respect to incident management structure including NIMS. All interviewees agreed that the technical unit organized to coordinate with IMAAC support staff was best-situated in the Planning Section of the NIMS organizational structure. This scientific situational planning unit (SITU) would consist of technically competent subject matter experts with exposure to the emergency response community. Experts from disciplines including fire, environmental, GIS, and public health would organize into a unit bridging the scientific gap between IMAAC support staff scientists and local jurisdictional operational

commanders. This construct was used successfully in Cincinnati during several training exercises and two serious hazardous materials incidents.[30]

Dayton Fire Department identified the line drawn between the incident scene and the IMAAC liaison situational planning unit such as Fayol's Bridge. Henri Fayol's theory of classical management describes a "dotted line" connecting organizational elements not necessarily connected by traditional hierarchical structure (Wikipedia, 2009). As such, Figure 4, OFM 4 has been revised as Figure 9 to properly identify Fayol's Bridge, connecting the incident scene to the locally positioned IMAAC SITU within the NIMS hierarchical structure.

H. FIGURE 4 OFM 4 RECOMMENDATION

1. For the mutual benefit of local jurisdictions and IMAAC, develop nationally recognized local jurisdiction-IMAAC coordinated procedures as originally identified in GAO–08–180 and as addressed in Figure 10, OFM 5, Blocks 1 and 2.

Figure 10 is a revision of Figure 5, OFM 5 (Chapter III Model) with findings from the interviews integrated into the newly revised figure.

[30] 2004—five alarm hazardous materials storage facility fire near downtown Cincinnati resulted in shelter-in-place direction being issued to surrounding neighborhoods; 2005—styrene railcar catastrophic release occurring on the eve of Hurricane Katrina and resulted in an evacuation of several hundred residents in Cincinnati's East End neighborhood.

Figure 10

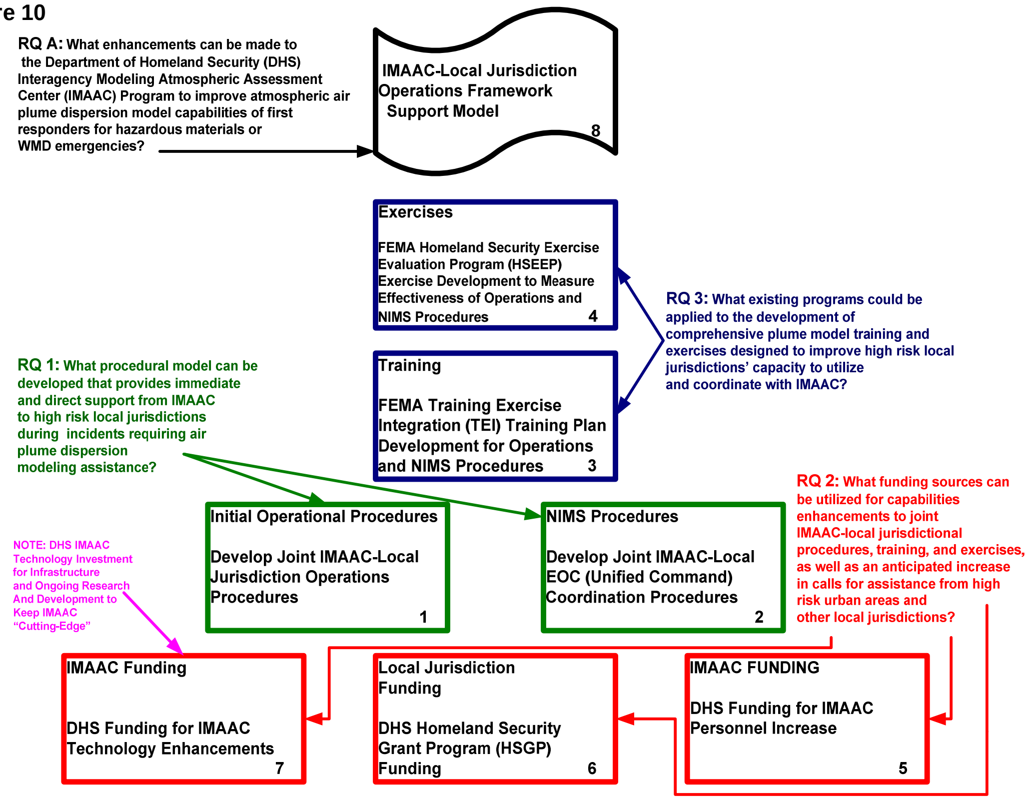

Figure 10. Operations Framework Model Revision 5

Figure 5 (OFM 5) (revised as Figure 10) is representative of necessary components to achieve the proposed objectives as represented in Figures 6, 7, 8, and 9. Procedures, training, exercises, and funding perspectives are the basis for Figure 5, OFM 5 and findings and recommendations for Figure 10.

I. FIGURE 5 OFM 5 FINDINGS

Interviewees were either neutral or entirely affirming of the ideas listed in Figure 5, OFM 5 Blocks 1, 2, 3, 4, and 6. Interviewees had no comment on Figure 5, Blocks 5 and 7.

Figure 5, OFM 5, Blocks 1, 2, 3, and 4 address immediate needs of local fire departments regarding overall support of Figure 5, Block 8, IMAAC-Local Jurisdiction Operations Framework Support. Interviewees affirmed the findings in GAO–08–180

regarding a need for development of IMAAC-local jurisdiction procedures, training, and exercises. Figure 5, OFM 5, Block 6 specifically identifies the FEMA Training Exercise Integration program as a logical place to begin training program development as was discussed in Chapter V. Development and institutionalization of an IMAAC local jurisdiction training course would allow the for the use of homeland security grant funds such as UASI or MMRS to be used in support of training content development and course delivery for local jurisdiction grant awardees. Interviewees were very supportive of this approach, emphasizing the importance of the potential utilization of homeland security grant funds to help ensure ongoing training. This is an area that cannot be ignored, but at the same time, it is an area that many local jurisdictions do not have excess general fund dollars with which to address related preparedness gaps. Two jurisdictions having enough familiarity with the FEMA TEI process and related training courses agreed that this would be an expeditious and effective process to move forward regarding training for IMAAC atmospheric air plume dispersion modeling.

Interviewees also concurred as to the importance of creating standard homeland security exercise plans that address IMAAC plume modeling preparedness gaps. Exercises designed on a much smaller scale, as compared to Top Officials Exercises, would be rooted in the FEMA HSEEP process. Interviewees noted the importance of adopting approved FEMA methodologies for training and exercises (FEMA TEI and HSEEP). This type of approach would help assure training uniformity while giving local jurisdictions a cost-neutral means of participant support by utilizing Urban Area Security Initiative, State Homeland Security Grant, and Metropolitan Medical Response System grant funds. Planning, execution, and lessons learned derived from FEMA Homeland Security Exercise Evaluation Program would also be useful in measuring procedure and training effectiveness.

No enhancements can take place to IMAAC without addressing funding considerations as represented in Figure 5, OFM 5, Blocks 5, 6, and 7 and also represented in Figure 10. Figure 10, Block 6 is representative of the DHS Homeland Security Grant Program already in effect for the nations’ 64 high risk urban areas, referred to as the Urban Area Security Initiative Program. Other HSGP funds could also be used by local

jurisdictions for plume model capacity enhancements and to educate, equip, train, and exercise emergency response agencies including local fire departments. As part of the UASI grant award program, it may be advisable to delineate a small percentage of already existing grant funds awards in order to bring local jurisdictions to an acceptable level of plume modeling planning and response capacity. Atmospheric air plume dispersion modeling is arguably an integral response element in seven of the 15 DHS National Planning Scenarios.[31] Arguably, for two DHS National Planning Scenarios, a toxic industrial chemical or a chlorine tank car explosion, atmospheric air plume dispersion modeling could become the single most critical life safety action immediately performed by emergency responders (i.e., local fire departments) in an incident involving a spill, release, or discharge whether accidental or intentional.

Regarding Figure 5, OFM 5, Blocks 5 and 7, and as represented in Figure 10, additional funding support will likely become necessary in order to expand IMAAC support staff to meet the needs of what is proposed by this thesis as the addition of several thousand IMAAC potential users requiring training. If all UASI jurisdictions for example are to be given IMAAC access, the total number needing access would equal the number of fire department command officers (64 cities) multiplied by the number of UASI cities. This number is not as foreboding as it might appear. Cincinnati has 25 command level officers that would mesh with the framework devised in Figures 6, 7, 8, and 9. If all 64 UASI cities had twice the number of command officers (50) as compared to Cincinnati, then the number to be trained for the entire UASI Program would equal roughly 3000 for the entire nation. Fifty per city is unrealistic as compared to Cincinnati, but no research was performed providing a realistic estimate so this number was projected arbitrarily high. Dispatch personnel would not require training by IMAAC as the most challenging dispatch center function would be to log on to the IMAAC website, access the plume prediction, and send an alert message—critical yes, but not requiring a voluminous training initiative. An IMAAC training program would not involve training for dispatch centers using emergency alert messages or reverse-911 systems.

[31] (1) Aerosol Anthrax; (2) Blister Agent; (3) Toxic Industrial Chemical; (4) Nerve Agent; (5) Chlorine Tank Explosion; (6) Radiological Dispersion Device; and (7) Improvised Explosive Device (FEMA, 2005).

Perhaps the biggest hurdle would be to enhance staffing and infrastructure for IMAAC at the interim location of Lawrence Livermore National Laboratories in Livermore, California. The National Atmospheric Release Advisory Center serves as the current interim host for IMAAC in partnership with the Department of Energy (DOE), the National Oceanic and Atmospheric Administration (NOAA), the Environmental Protection Agency (EPA), the Department of Defense (DoD), the National Aeronautics and Space Administration (NASA), the Nuclear Regulatory Commission (NRC), and the Department of Health and Human Services (HHS). Admittedly, this researcher is a neophyte regarding federal agency constructs and respective budgets. However, it may be possible for each agency, in keeping with the legitimate emphasis of Homeland Security Presidential Directive 5, to cooperatively support the IMAAC mission on behalf of the first responder community. Furthermore, the appropriate directorate(s) within DHS may be able to identify funding to substantively address IMAAC capabilities enhancements which address critical functional elements of seven of the 15 National Planning Scenarios, and 15 of the 37 critical capabilities listed on the DHS Target Capabilities List (TCL).[32]

Expanding national atmospheric air plume dispersion modeling capacity can work as a collaborative partnership between DHS, partnering federal agencies, and local jurisdictions. Local jurisdictions shall supply the personnel and become equipped, educated, trained, and exercised with IMAAC and in the context of the DHS Urban Area Security Initiative, State Homeland Security Grant, and Metropolitan Medical Response System Homeland Security Grant Program awards. An adequate percentage of locally awarded homeland security grant funds will be used by UASI and MMRS[33] jurisdictions

[32] (1) Risk Management (2) CBRNE Detection (3) Critical Infrastructure Protection (4) Food and Agriculture Safety and Defense (5) Epidemiological Surveillance and Investigation (6) On-Site Incident Management **(7) Responder Safety and Health (8) Emergency Public Safety and Security** (9) Environmental Health (10) Explosive Device Operations (11) Fire Incident Response Support **(12) WMD and Hazardous Materials Response and Decontamination (13) Citizen Evacuation and Shelter in Place (14) Emergency Public Information and Warning** (15) Medical Surge (FEMA, 2009).

[33] So as not exclude smaller high risk jurisdictions, an MMRS jurisdiction could opt in or out of the IMAAC initiative. By opting in, full IMAAC access is granted along with IMAAC emergency incident and training support. By opting out, an MMRS will not have IMAAC access. Access would be virtually pointless absent coordinated procedures reinforced through training and exercises setting up a repeat of historical failures experienced during Top Officials Exercises which would likely reoccur with jurisdictions under such circumstances.

to accomplish all of the above. DHS will work with the other IMAAC partner agencies to identify funding sources allowing for the infrastructure upgrades and personnel enhancements to the IMAAC program in the interests of local, state, and federal emergency responders. This type of quid pro quo arrangement could prove advantageous effectively compelling local, state, and federal partners to assume collective ownership of the national capacity for atmospheric air plume dispersion modeling.

J. FIGURE 5 OFM 5 RECOMMENDATIONS

1. Beginning in FY 2011 and FY 2012, the Department of Homeland Security should fund two fellowships with representatives from local jurisdictions and coordinated by the Naval Postgraduate School with the IMAAC program.

2. Beginning with the FY 2012, HSGP awards should require all UASI awardees to coordinate spending of 2.5 percent of the respective UASI and SHSG locally-distributed grant awards for enhancement of atmospheric air plume dispersion modeling capacity and as designed by IMAAC in partnership with their DHS fellows.

3. If recommendations one and two are not feasible, the following is recommended:

    a. In Cincinnati, DHS should work in partnership with Cincinnati Urban Area Leadership to convene a randomly selected, but statistically-significant, UASI stakeholder group comprised of the highest ranking UASI fire department atmospheric air plume dispersion model subject matter experts to vet operational plume modeling deficiencies while exploring viable solutions using a neutral professional facilitator from the private sector (e.g., volunteers from the Proctor and Gamble Corporation).

    b. In Cincinnati and concurrently with recommendation one, DHS should request the eight IMAAC partnering agencies to convene in a facilitated process using a neutral professional facilitator from the private sector (e.g., volunteers from the Proctor and Gamble Corporation). This meeting will be separate but in close proximity to the group listed in recommendation one, and in the event that the facilitators identify some common ground that may be synergized in support of the IMAAC mission. The purpose of this group will be to identify realistic low cost and no cost solutions to enhance IMAAC infrastructure, personnel, and redundancy in both the short- and long-term.

c. Findings should be evaluated by the professional volunteer facilitators and the respective groups will reconvene two weeks later with meeting agendas formulated subject to meeting findings used for identification of potential next steps.

These three recommendations are viewed as a realistic approach to moving forward with respect to enhancing national atmospheric air plume dispersion modeling capabilities at federal, state, and local levels.

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